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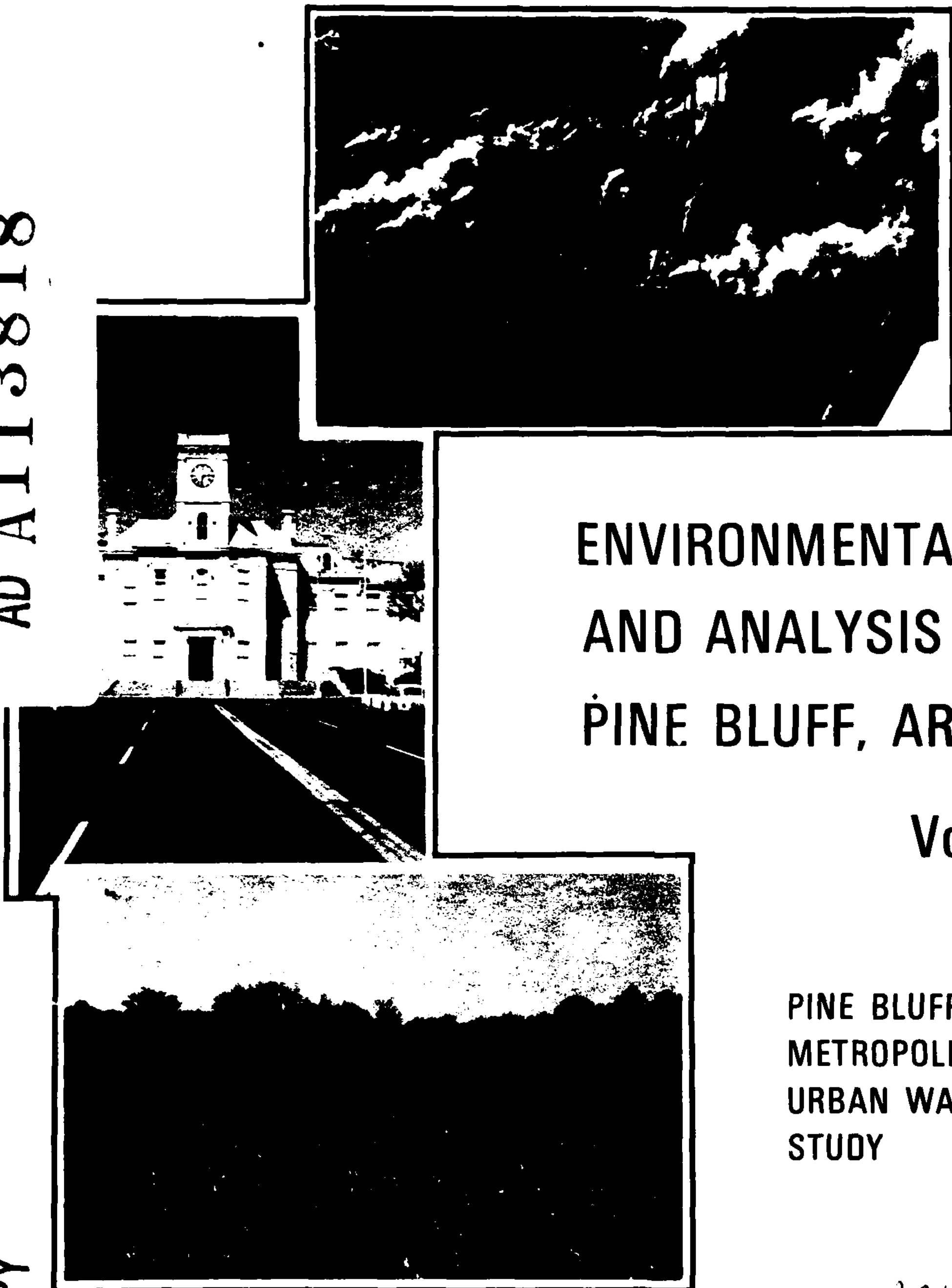

# ENVIRONMENTAL INVENTORY AND ANALYSIS FOR PINE BLUFF, ARKANSAS

## Volume I

PINE BLUFF
METROPOLITAN AREA, ARKANSAS
URBAN WATER MANAGEMENT
STUDY

DACW38-74-C-0139





PREPARED FOR THE
**DEPARTMENT OF THE ARMY**
**VICKSBURG DISTRICT, CORPS OF ENGINEERS**



vtn louisiana

*Let no man jump to the conclusion that he must take his Ph. D. in ecology before he can "see" his country . . . . The weeds in a city lot convey the same lesson as the redwoods; the farmer may see in his cow-pasture what may not be vouchsafed to the scientist adventuring in the South Seas. Perception, in short, cannot be purchased with either learned degrees or dollars; it grows at home as well as abroad, and he who has a little may use it to as good advantage as he who has much.*

*Aldo Leopold*

# ERRATA

## ENVIRONMENTAL INVENTORY
## AND ANALYSIS FOR PINE BLUFF, ARKANSAS

### Volume I

| PAGE | PARAGRAPH | LINE | CHANGE |
|---|---|---|---|
| ii | 2 | 4 | Change "Mr. J. Click, Sr." to "Mr. W. G. Click, Sr." |
| ii | 2 | 14 | Change "Arkansas Geologic Commission" to "Arkansas Geological Commission" |
| ii | 3 | 4 | Change "Mr. Jerry Click, Jr." to "Mr. W. G. Click, Jr." |
| II-24 | - | - | Add the following paragraph under Climatic Hazards:<br>(6) Ice Storms.<br>Although not frequent in occurrence, ice storms sometimes have a major economic impact on the area. Problems include transportation on ice covered roads, loss of utilities including water, electricity and phone service, and damage to vegetation including pine trees, shade trees, and ornamental shrubs. Due to their rare occurrence, residents are generally poorly prepared for such emergencies aggravating the situation. |
| II-53 | 7 | 3 | Change "Selene County" to "Saline County" |
| II-55 | 3 | 2 | Change "Quaternary" to "Tertiary" |
| II-55 | 3 | 5 | Change "Quaternary" to "Tertiary" |
| III-3 | - | - | Lake Pine Bluff should be labeled "PR" |
| V-2 | - | - | Air quality data indicated as "$mg/m^3$" Change to "$\mu g/m^3$" |
| V-7 | - | - | Same as above |
| V-8 | - | - | Same as above |
| XII-9 | - | 6-7 | Add "Smithsonian Institute. 1975. Report on Endangered and Threatened Plant Species of the United States. U.S. Government Print. Office, Washington, D.C." |

vtn Engineers Planners Environmental Scientists
2701 Independence Street, Metairie, Louisiana 70002 (504) 455-3881

October 3, 1975

Colonel Gerald E. Galloway
District Engineer
Corps of Engineers, Vicksburg District
P.O. Box 60
Vicksburg, Mississippi 39180

ATTN: LMKED-PC/LKMED-AA

RE: Contract No. DACW38-74-C-0139
Environmental Inventory and Analysis of
the Pine Bluff Metropolitan Area, Arkansas

Dear Colonel Galloway:

VTN is pleased to submit herewith this Final Report entitled "Environmental Inventory and Analysis Pine Bluff Metropolitan Area, Arkansas." This report consists of two principal documents identified as Volume 1, the main body of the report, and the companion document Volume 2: Appendices. This report and the supportative appendices have been prepared in accordance with the referenced contract, and in conformance with the agreed upon scope of work. Extensive files and notebooks of field data developed during the study have also been submitted to your staff, under separate cover, for the Corps technical reference file on the project.

The report presents the results of an intensive environmental monitoring program in the Pine Bluff study area which began in March, 1974. The analysis of this environmental data provides a basis for understanding the environmental conditions in the study area, which in turn will assist in making decisions on initiating development actions in and near the city of Pine Bluff. The report also provides the city of Pine Bluff, the Corps of Engineers and other public agencies, citizen groups, and individuals a comprehensive environmental baseline which may be utilized as a common reference in consideration of the overall water management problems of the study area, and for preparation of environmental impact statements for development plans, which may be prepared to solve these problems.

Colonel Gerald E. Galloway
October 3, 1975
Page -2-

This report was submitted to you on May 22, 1975 as a draft environmental inventory and analysis, and has been subsequently revised to incorporate appropriate review comments from your staff and other interested agencies and groups. Note that the report has a summary at the end of each major subsection to facilitate understanding and speed of reading of the report. It is imperative to note that the study has been presented as a technical report, written for use by the Corps' staff of engineers, planners, and environmental scientists who have the working knowledge of the terminology, methodology and study purpose, which are essential to the assessment of the engineering and environmental elements of the urban water management study. However, VTN has also made a conscious effort to make the report readable for general usage.

We acknowledge that the Vicksburg District Corps of Engineers and the citizens of Pine Bluff have demonstrated that they are, and have been, aware of the environmental setting in the study area, and are aware of a responsibility to the community for protection of the existing and potential environmental values of the area. It has been a pleasure to serve the Vicksburg District in this important planning program, and we look forward with you to the achievement of plans that are compatible with the present and future environment of the Pine Bluff Metropolitan Area.

Respectfully submitted,

VTN LOUISIANA, INC.

Terry J. Hartman, P.E.
President

VTN

# ENVIRONMENTAL INVENTORY AND ANALYSIS FOR PINE BLUFF, ARKANSAS VOLUME I

## PINE BLUFF METROPOLITAN AREA, ARKANSAS URBAN WATER MANAGEMENT STUDY

OCTOBER 1975

PREPARED FOR THE

**DEPARTMENT OF THE ARMY**
**VICKSBURG DISTRICT, CORPS OF ENGINEERS**

vtn louisiana

# ACKNOWLEDGMENTS

The inestimable contributions of Mrs. Jane Stern, Chairperson for the Citizens Advisory Committee and Mrs. Marie Locke, Co-coordinator of vegetational studies are gratefully acknowledged. All members of the Citizens Advisory Committee are acknowledged for their numerous contributions. Special acknowledgment is given to Mr. John Hogue, biologist for the Arkansas Department of Fish and Game; Mr. Arthur Holmes and Mr. Dennis Vogt and all members of the Southeast Arkansas Regional Planning Commission; Mr. Vaughn Black, director of the Parks and Recreation Department; Mr. Andrew Crossett, Soil Conservation Service; and Mr. T.E. Neeley, Pine Bluff coon-hunter and businessman.

Other acknowledged contributors include: Mr. Bill Bauknight, University of Arkansas, Pine Bluff; Dr. Ken Beadle, Arkansas State University, State University; Dr. M.S. Bhangoo, University of Arkansas, Pine Bluff Soils Laboratory; Mr. Jim Chambers, U.S. Army Corps of Engineers; Mr. J. Click, Sr., Pine Bluff Arsenal; Mr. H.V. Gill, U.S. Soil Conservation Service; Mr. H. Halberg, U.S. Geological Survey; Mr. Philip Klopfenstein and the Jefferson County Historical Commission; Mr. Jim Lamont, Pine Bluff Street Department; Mr. Ken Manuel, Pine Bluff Arsenal; Dr. Tim Matzke, Environmental Protection Agency, Region VI; Mr. Carl McGrew, U.S. Soil Conservation Service; Mr. John Pitts, Pine Bluff Street Department; Mr. Murray Reichen, General Waterworks Corporation; Mr. T.J. Rowell, City Engineer, Pine Bluff; Dr. E.B. Smith, University of Arkansas, Fayetteville; Dr. Han Tai, U.S. Pesticide Monitoring Laboratory, Bay St. Louis, Mississippi; Mr. John T. Watts, Pine Bluff Arsenal; Mr. Norman Williams, Arkansas Geologic Commission.

The VTN study team included: Dr. Robert S. Irving and Dr. Mary G. Curry, Environmental Scientists; Mr. David Arnoldi and Mr. Ellis Clairain, Jr., Environmental Specialists; Mr. Greg Rigamer, Urban and Regional Planner; Mr. James Leemann, Environmental Engineer; Mr. Jerry Click, Jr. and Mr. Billy Ashcraft, Environmental Assistants; Dr. Joseph Nix, Consulting Chemist, and Mr. Burney B. McClurkan, Survey Archeologist for the Arkansas Archeological Survey.

To persons and groups not mentioned, our apologies and appreciation.

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# INTRODUCTION I

# I
# INTRODUCTION

## A. THE PINE BLUFF METROPOLITAN AREA, ARKANSAS URBAN WATER MANAGMENT STUDY.

The Pine Bluff Environmental Inventory and Analysis is a part of the overall Pine Bluff Metropolitan Area Urban Water Management Study being conducted by the Vicksburg District, U.S. Army Corps of Engineers. Nationwide, the Corps of Engineers has been directed by Congress to use its planning capabilities in helping metropolitan areas solve their water and related land resource problems. This new mission of the Corps, known as the Urban Studies Program, began in 1972. The Urban Studies Program is a further extension of the Corps' planning responsibilities for flood control, navigation, hydroelectric power, water conservation, recreation, and water-oriented environmental quality. The Corps will continue planning for basinwide water resource development, in addition to carrying out the Urban Studies Program.

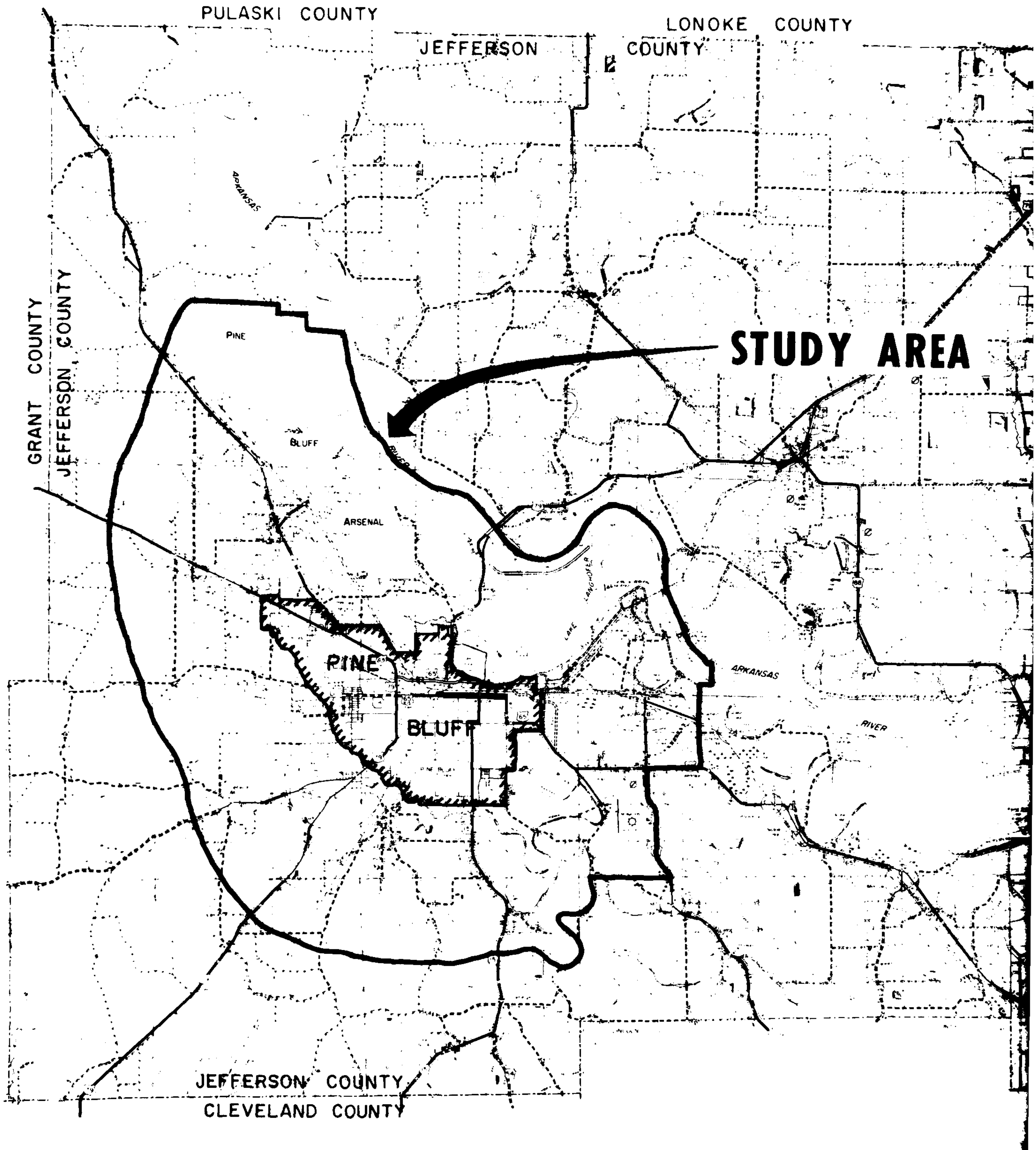
The Pine Bluff Urban Study is being conducted in response to a Senate Public Works Committee resolution adopted 29 December 1971. The study's goal is to provide for the timely and efficient development of water and related land resources in the Pine Bluff Metropolitan Area while maintaining a quality environment. The study will address the following water resource areas: flood control and reduction of flood damages, water supply, enhancement of water quality, navigation facilities, waste water management, water-oriented recreation, and enhancement of environmental quality.

An important segment of the Vicksburg District's overall Pine Bluff study is the establishment of baseline environmental, economic, and social conditions in the Study Area. An inventory and analysis of these conditions and their interrelationships is the cornerstone for developing alternative solutions to the water and related land resource problems of the Pine Bluff Metropolitan Area.

## B. THE STUDY AREA: BACKGROUND AND DEFINITION.

The Pine Bluff Metropolitan Area is located in Jefferson County in southeast Arkansas along the south bank of the Arkansas River approximately 40 miles southeast of Little Rock (Figure I-1). The area of study, ranging from flat to gently rolling lands, occupies a portion of the floodplain of the Arkansas River and adjacent highlands which form the western wall of the Mississippi River alluvial valley. The "Study Area" referenced throughout this report encompasses approximately 200 square miles, defined by the natural boundaries of drainage basin areas.

The drainage patterns follow the undulating topography and slope from northwest to southeast. The major components of the drainage network include the Arkansas River, Caney Bayou, and Brumps Bayou to the north, and Bayou Bartholomew to the south. There are also a number of man-made drainage arteries draining the City of Pine Bluff. The two major lakes in the area are Lake Pine Bluff and Lake Langhofer (slack water harbor).

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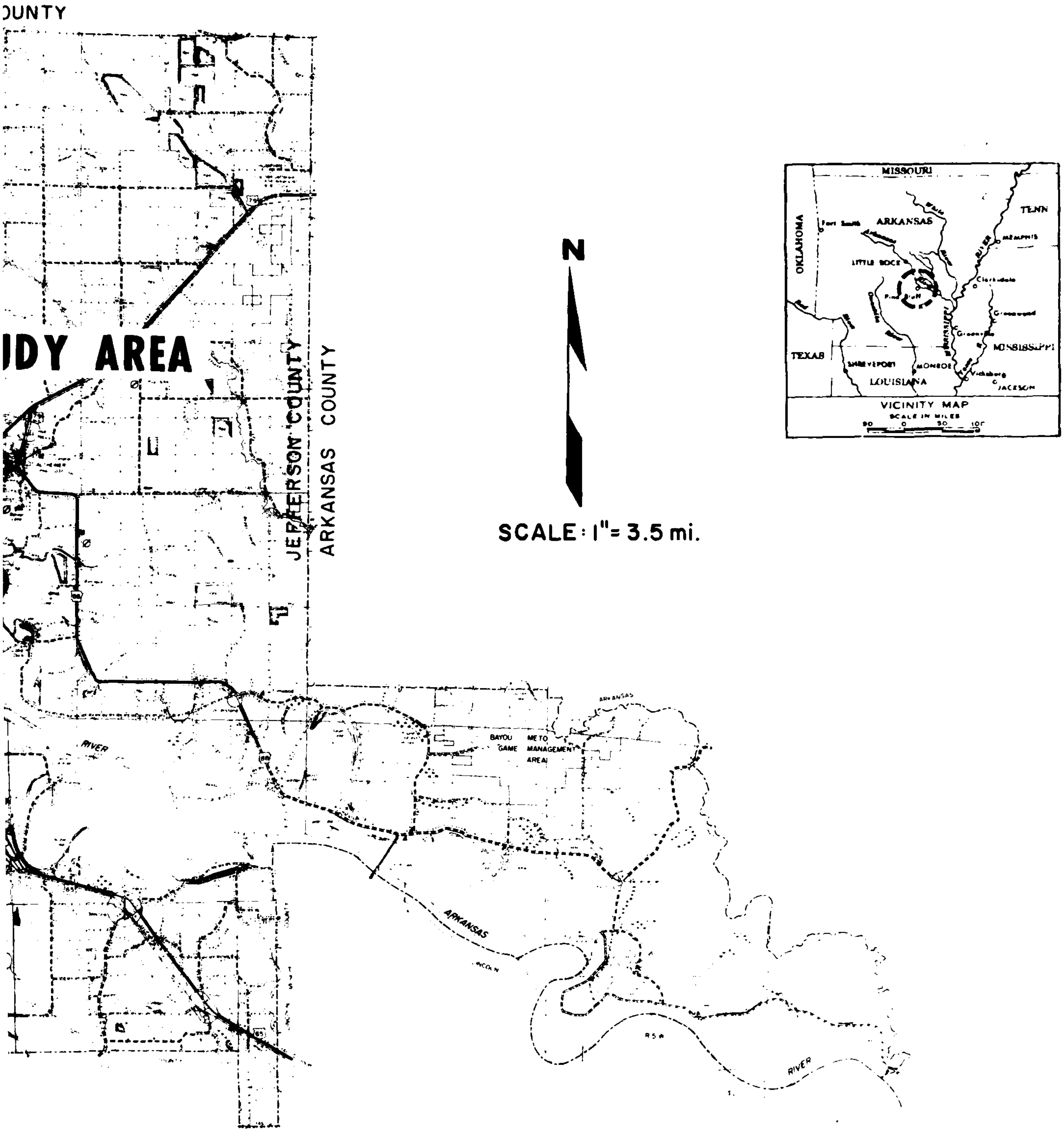



E BLUFF STUDY AREA
ND LOCATION MAP

**FIG. I-1**

2

The population is in excess of 75,000 and the economic base is well diversified. Transportation corridors include Federal, State and local roads, two major railroads and a municipal airport. Pine Bluff is the first port on the Arkansas River and has the only slack water harbor along the waterway.

The Study Area has potential for the development of its water and land resources. Aquifers in the area are major water sources for public, industrial and agricultural uses. In addition, the many streams, lakes and ponds offer considerable recreational opportunity and the Arkansas River serves as a major transportation route. The fertile alluvial lands to the south and east are favorable for growing cotton, soybeans and rice, and for grazing livestock. To the north and west, pine and hardwood forests have encouraged growth of the area's principal industries: lumber and wood products.

Much of the land and water resources of the area provide habitat for a variety of wildlife species and form the cornerstone of environmental quality. The mixed hardwoods support important wildlife populations, and Bayou Bartholomew provides scenic beauty and a valuable fish and wildlife habitat. Overflow lands, including associated lakes and streams, also support species of migratory waterfowl. Moreover, the waters throughout the area support populations of fish and other aquatic life.

Despite the abundance of land and water resources and their potential to support growth, the Study Area is not without problems and immediate needs. The City of Pine Bluff, like many urban areas, is experiencing an influx of population from rural areas. This results in an increased demand on the area's resources and affects the economy as well as the environment. Residents of the central city area are moving to suburban areas, leaving concentrations of low income families, relatively high unemployment, deteriorating housing and other symptoms of urban blight. Developments arising to accommodate this shifting population have often proceeded without adequate consideration of consequent adverse effects.

Although flood protection has been substantially increased by levees along the Arkansas River over the past few decades, flooding in the area still occurs; especially along Bayou Bartholomew. Compounding the problem, urban development has accelerated in recent years, in and adjacent to the Bayou Bartholomew flood plain, and has created a condition in which a major flood would be devastating.

Local flooding in the Study Area is due to poorly developed drainage patterns. This becomes especially critical when runoff destined for the Arkansas River must, during high stages, be diverted into Bayou Bartholomew. Flooding from a lack of adequate drainage also occurs along several other streams.

Ground water resources, although currently adequate, are also beginning to reflect the problems of urban growth and industrialization. During drought periods, some ground water shortages do occur and large withdrawals have created a major cone of depression in the deep well aquifer. This has resulted in increased pumping lifts and continually declining water levels.

Surface water quality in the principal streams varies with location and streamflow. Storm runoff from the Pine Bluff area adversely affects the quality of the receiving waters. Moreover, there is evidence of agricultural encroachment along the banks replacing the natural greenbelts. Sediment and turbidity from this source have also affected water quality.

Sanitary sewer service in the Study Area is limited to Pine Bluff. Most of the domestic sewage disposal needs outside this area are met by the use of septic tanks and leaching fields. However, most of the soil in the area has relatively poor permeability and does not lend itself to this type of disposal. In addition, in many locations, the water table is too near the ground surface. For these reasons, health authorities consider the septic tank-leaching field method a poor substitute for a public sanitary sewer system. Also, the existing sanitary sewer system has problems of surface water infiltration. There are many other problems and concerns facing the Pine Bluff Urban Study Area: the further development of the Pine Bluff Port; the preservation and enhancement of the area's cultural resources, scenic areas and valuable wildlife habitats; and the continued development of Pine Bluff's land and water recreation facilities.

The boundaries of the Study Area are based on hydrologic features and the approximate extent of land directly influenced by existing and anticipated urban development. The northern boundary is formed by the north bank of the Arkansas River and the northern limit of the U.S. Army Pine Bluff Arsenal. The western boundary is formed by the western drainage divide of the upper Bayou Bartholomew River Basin. The southern boundary is formed by the northern divide of the Sandy Bayou watershed and Boggy Bayou from its confluence with Sandy Bayou to Bayou Bartholomew. The eastern boundary is formed by a portion of Bayou Bartholomew and man-made features anticipated as limits of urban-related growth. Because most of the Study Area lies either in the upper extreme of the Bayou Bartholomew Basin or in the Caney Bayou Basin, which it completely encompasses, the Study Area is relatively unaffected by upstream hydrologic conditions. The notable exception to this is the Arkansas River, which forms the northern boundary. The Arkansas River has decisive effects on various aspects of the area's resources, particularly navigation and flood control. The portion of the Bayou Bartholomew Basin lying below the Study Area is affected by the amount and type of development in the Study Area.

## C. ORGANIZATION OF THE ENVIRONMENTAL INVENTORY AND ANALYSIS.

The report is divided into eleven sections which merge the objectives of both inventory and analysis phases. Because of the emphasis on water management each section, where applicable, is organized by hydrologic unit. Sections II through VI and VIII through X assess the various environmental elements and their relationships to the Study Area. Section VII summarizes the various interrelationships and calls attention to the National and regional significance of environmental elements and their potentials and limitations. Section XI summarizes the important role of public participation. A glossary, bibliography and appendices are provided.

# PHYSICAL SETTING AND PHYSICAL RESOURCES

# II

# II
# PHYSICAL SETTING & PHYSICAL RESOURCES

## A. INTRODUCTION.

This section considers the inter- and intrarelationships of the physical environment in the Pine Bluff Study Area. Particular detail has been given to the geologic, pedologic and hydrologic resources, with special interest devoted to geomorphology, surface and subsurface geology, unique geologic features, geologic hazards, economic geology, soil associations, climate, and surface and ground water resources, including use and consumption. A discussion is presented on the findings made during the inventory phase of the study, followed by the relationships of the physical resources to the existing setting of the Study Area and the effects they may have on its future conditions.

## B. GEOLOGICAL RESOURCES.

The geological resources are those of Jefferson County and, where applicable, the Study Area. The discussion includes descriptions and illustrations of the physiography, geomorphology, surface and subsurface stratigraphy, unusual geologic features, economic geology, geologic hazards and how these resources relate to the future of the Study Area.

### 1. Physiography and Geomorphology.

#### a. General Description.

The Study Area is comprised of approximately 200 square miles and is located totally within Jefferson County, Arkansas, in the southeast-central portion of the State. The Study Area straddles the West Gulf Coastal Plain to the west and the Mississippi Alluvial Plain to the east (Figure II-1). The West Gulf Coastal Plain is characterized as a gently rolling surface, moderately dissected by streams. Much of the surface material is unconsolidated sands deposited in the sea which once covered the area. The Mississippi Alluvial Plain is a trough filled by stream sediments of great depth. Figure II-2 presents the physiographic regions of Arkansas and illustrates how these regions relate to Jefferson County and the Study Area.

#### b. Elevations and Relief.

The Study Area is moderate to low in relief, ranging in elevation from 200 to 400 feet above sea level. The Jacksonian Stage outcroppings form the Monticello Ridge (Figure II-3) along the western boundary of the Study Area. Altitudes along the crest of the ridge average about 300 feet above sea level, but locally rise to slightly more than 400 feet where Pliocene deposits cap the Jackson Group. From an elevation of about 200 feet above sea level at Pine Bluff, the alluvial plain slopes southward at slightly less than one foot per mile to an altitude of about 100 feet above sea level at the Arkansas-Louisiana state line (Broom and Reed, 1973).

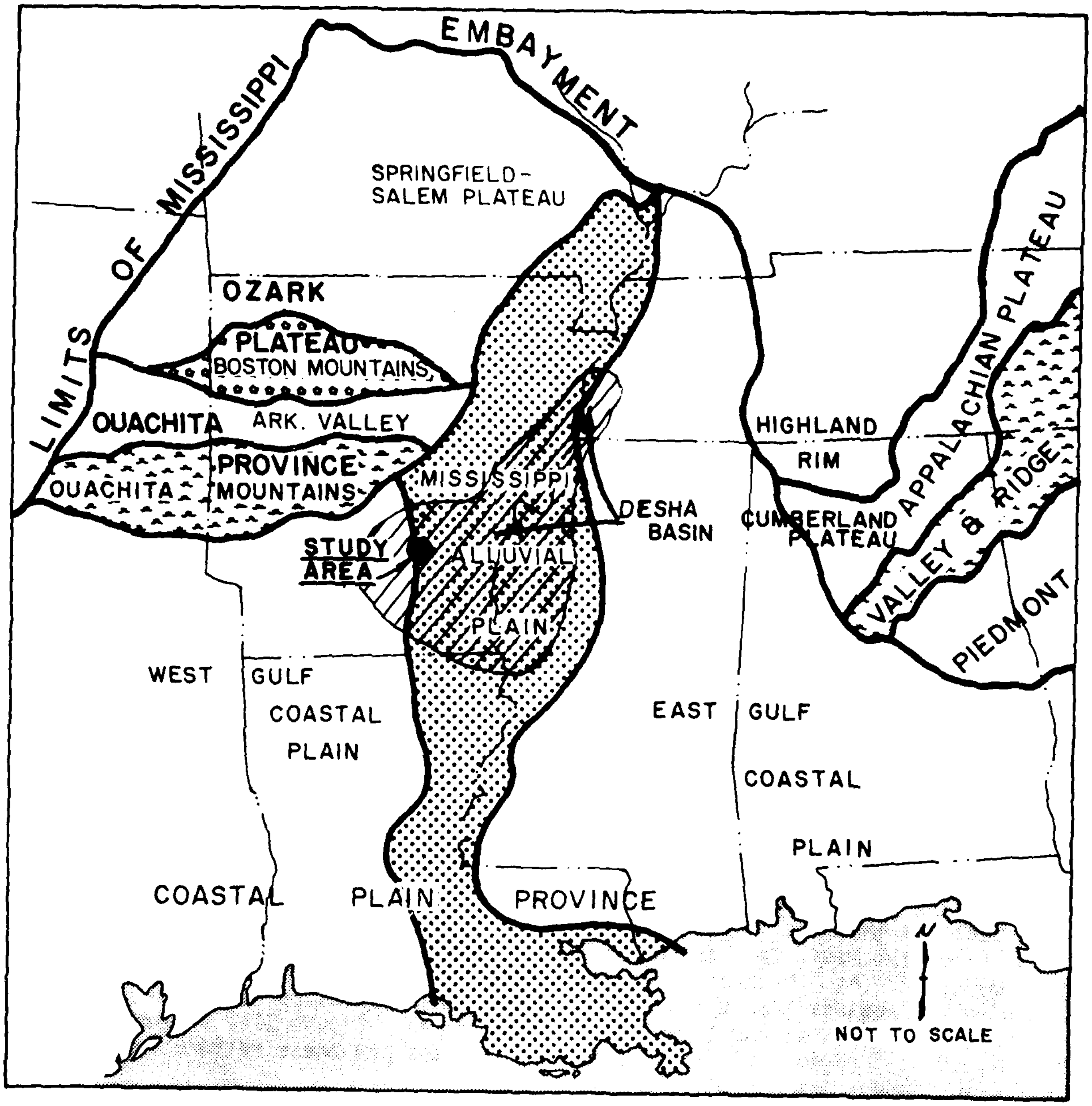



FIGURE II-1: MAJOR PHYSIOGRAPHIC DIVISIONS OF THE CENTRAL GULF STATES

Source: Moore, 1966.

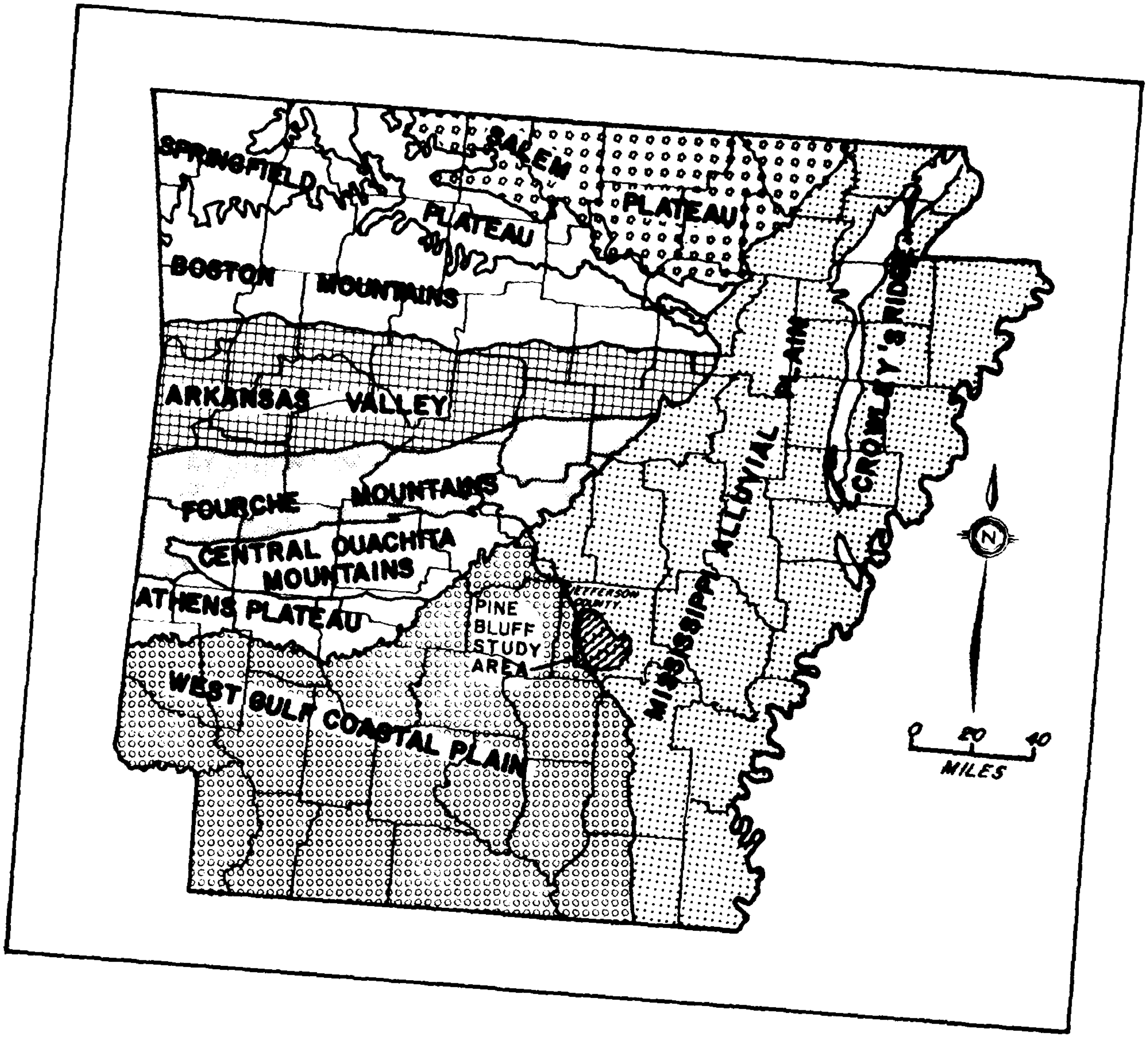



FIGURE II-2: PHYSIOGRAPHIC REGIONS OF ARKANSAS

Source: Arkansas Geological Commission, 1973.

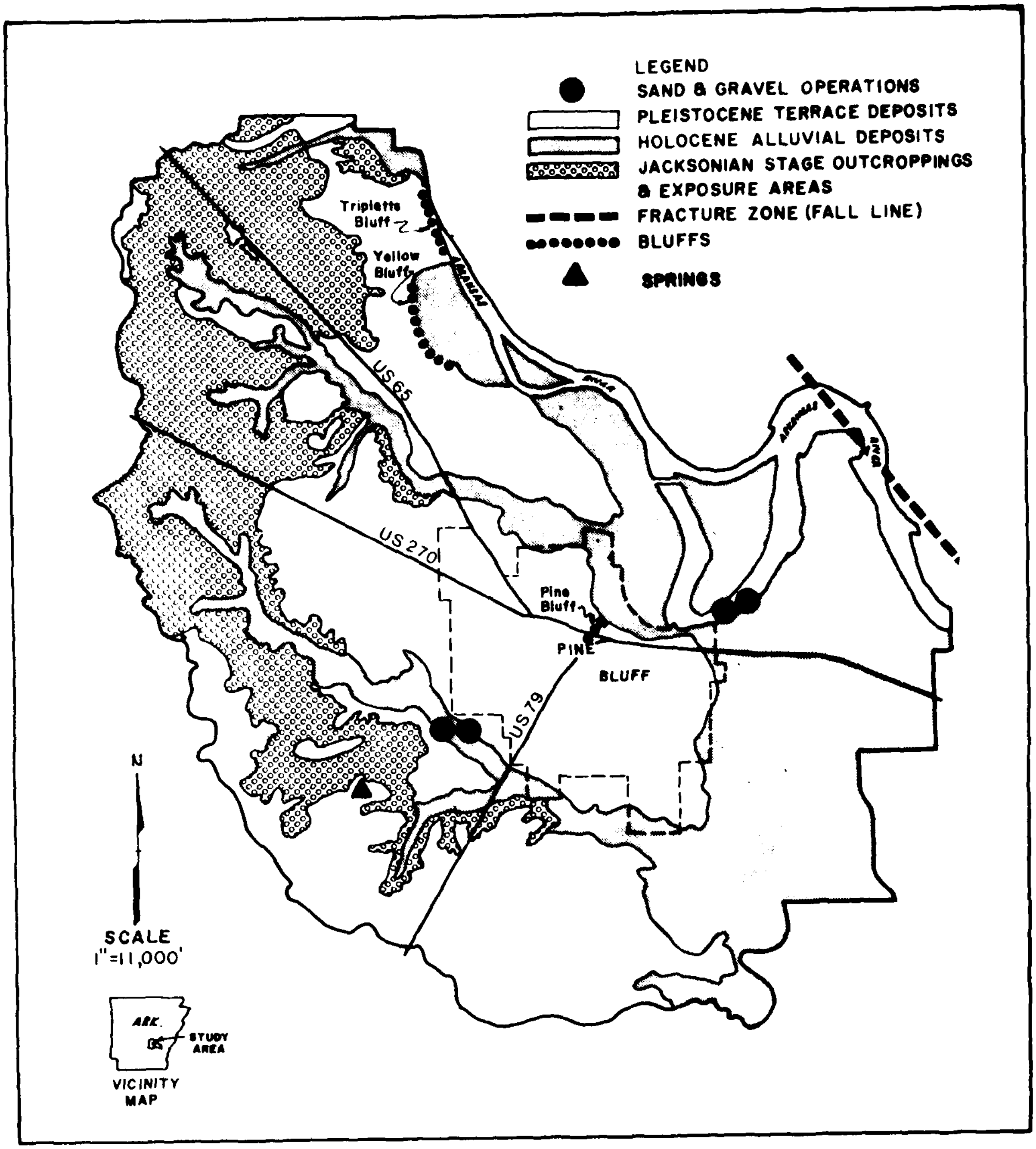



FIGURE II-3: SURFACE GEOLOGY OF THE PINE BLUFF STUDY AREA

Source: Clardy and Bush, 1974.

c. Geomorphic History.

In early Paleozoic time (Figure II-4), Arkansas was covered by a large sea which was bounded on the north and south by large land masses. From Cambrian through Pennsylvanian times (Figure II-4), the area received marine deposits which are now represented by sandstone, shale, chert and limestone. The land masses began moving together during late Paleozoic time and formed the Ouachita Mountain chain. Subaerial erosion for the next 180 million years reduced the former folded and sheared rock mountains into low hills. During Permian, Triassic, Jurassic and Lower Cretaceous times (Figure II-4), Jefferson County was above sea level and was subjected to extensive erosion; hence, none of the previously mentioned sediments are found there.

(1) The Mississippi Embayment.

The Mississippi Embayment, a large structural depression, was probably formed during the Cretaceous period at some time prior to the deposition of earliest Upper Cretaceous sediments (Caplan, 1954). Southward downwarping probably was the first step in the embayment formation. Subsequent downwarping east of the present Mississippi River course resulted in the formation of the Arkansas coastal plain and, ultimately, in the development of the embayment. These movements of Paleozoic rocks resulted in the troughlike syncline of the embayment which approximates the present Mississippi River course (Wilbert, 1953; Figure II-1).

(2) The Desha Basin.

During Upper Cretaceous time, an asymmetrical basin was formed in the area of Desha, eastern Lincoln and southeastern Jefferson counties after the occurrence of downwarping in the Mississippi structural trough and upwarping of the adjacent Monroe uplift (Wilbert, 1953). This depression, known as the Desha Basin (Figure II-1 ), can be evidenced by the depth of Tertiary and Quaternary sediments covering the Paleozoic bedrock in eastern Jefferson County. In the western part of the county, about 2,000 feet of sediments cover the bedrock; in the extreme eastern portions of Jefferson County, the Paleozoic rocks are overlain by 4,000 feet of sediments. This basin may have been instrumental in controlling Upper Cretaceous deposition in southeast Arkansas. Marine deposition was predominant during the Upper Cretaceous and Paleocene times.

(3) The Jacksonian Stage.

Continental erosion (primarily from the Ouachita Mountains) was predominant after Upper Cretaceous marine deposition ceased; thick deltaic beds of the Wilcox and Claiborne groups were deposited. The final marine inundation of the area occurred during the Jacksonian time. After Jackson stage deposition ceased, the Desha Basin ceased to function as a depositional center (Wilbert, 1953). The eastern two-thirds of Jefferson County then received alluvium from Quaternary fluviatile activity.

(4) The Quaternary Period.

Early in the Quaternary, the waters from the continent flowed rapidly toward the sea in eastern Arkansas due to a relatively steep gradient. This is evidenced by the nature of the bottom gravel deposits in the alluvium. As the

Figure II-4
General Stratigraphic Column of the Study Area

| ERA | SYSTEM | SERIES | GROUP | FORMATION | RADIOMETRIC DATES | THICKNESS (FT.) |
|---|---|---|---|---|---|---|
| Cenozoic | Quaternary | Holocene | Alluvium | Alluvium | | 0-250 |
| | | Pleistocene | Quaternary Terrace | Undifferentiated | 2,000,000 Years B.P. | |
| | Tertiary | Eocene | Jackson | Undifferentiated | | 100-300 |
| | | | Claiborne | Cockfield | | 200 |
| | | | | Cook Mountain | | < 200 |
| | | | | Sparta Sand | | 450-800 |
| | | | | Cane River | | 150-400 |
| | | | | Carrizo Sand | 55,000,000 Years B.P. | 100-300 |
| | | | Wilcox | Undifferentiated | | 750-950 |
| | | Paleocene | Midway | Porters Creek | | 400-500 |
| | | | | Clayton | 65,000,000 Years B.P. | 35 |
| Mesozoic | Cretaceous | Gulf | Navarro | Arkadelphia | | 50 |
| | | | | Nacatoch | | 0-380 |
| | | | Taylor | Saratoga | | 0-125 |
| | | | | Marlbrook | | 0-150 |
| | | | | Annona | | 0- 85 |
| | | | | Ozan | | < 150 |
| | | | Austin | Basal Detrital Unit Pre-Ozan | 225,000,000 Years B.P. | 0-150 |
| Paleo-zoic | Cambrian through Pennsylvanian | | | | 600,000,000 Years B.P. | |
| | Pre-Cambrian | | | | 4,500,000,000 Years B.P. | |

Source: Modified from Caplan, 1954 and Dunbar and Waage, 1969.

gradient decreased, the waters slowed and, eventually, carried deposits of mostly fine sands and silts to the areas of eastern Jefferson County. Recent activity in the eastern Jefferson County area has been characterized by meanderings of the Arkansas River. Abandoned channels, oxbow lakes, wetland areas and low natural levees were formed during this time. To the south of Pine Bluff, Bayou Bartholomew presently occupies an old Arkansas River channel. Since the disasterous floods of 1927, levees were constructed along the Arkansas River south of the Pine Bluff area. Since then, alluvial deposition has been limited to the floodplain areas of the Arkansas River.

2. Geologic Formations.

Several geologic units are exposed in the Study Area. These units include Holocene (Recent) alluvial deposits, Pleistocene terrace deposits and Jacksonian stage outcroppings as illustrated on Figure II-3. A generalized stratigraphic column is presented in Figure II-4.

a. Surface Stratigraphy.

Jefferson County and the Study Area are composed of Quaternary deposits consisting of Pleistocene terrace deposits, which occur between the Arkansas River and the outcrop area of the Jackson formation, and Holocene (Recent) alluvial deposits which blanket most of the eastern part of the Study Area and the county. Both the Pleistocene and Holocene (Recent) deposits are represented by a sequence of fluviatile deposits which grade upward from coarse graveliferous sands through a central sand section into overlying silts and clays. No attempt has been made to differentiate the Pleistocene formations. The older fluviatile formations have been uplifted to form terraces in the uplands and only the youngest occur in the bottomlands in the eastern part of the Study Area (Fisk, 1944). The Quaternary deposits are approximately 250 feet thick. In the western section of the Study Area and in Jefferson County, the Jackson group outcrops. Deposits of the Jacksonian Stage are the youngest of the Tertiary sediments generally identified in this region. Jacksonian beds in southeastern Arkansas are both marine and nonmarine throughout most of the Mississippi Embayment, and recognizable marine fossils are found as far north as the latitude of Memphis, Tennessee. Unlike older Tertiary units, Jacksonian strata are not traceable on the surface from the coastwise belts into the embayment. All marine Jacksonian beds within the Mississippi Embayment outcrop as isolated inliers west of the Mississippi River as is the case in the Study Area (Figure II-3). The marine strata are composed of calcareous glauconitic clay or argillaceous greensand, containing an abundant and varied invertebrate fauna, overlain by dark gray argillaceous sand containing many molluscan remains and overlain by thin-bedded silty clay and blocky clay beds, characterized by discontinuous, thin, molluscan remains. The nonmarine strata exhibit lithologic characteristics of nonmarine-type sedimentation in the Gulf Coastal Plain. Thin-bedded lignitic silts, containing fossil leaves, cross-bedded sands, and discontinuous thin beds of lignite are diversely developed within the unit (Wilbert, 1953). The Jackson group is between 100 and 300 feet thick.

b. Subsurface Stratigraphy.

The subsurface geology of Jefferson County is similar to that of other Arkansas counties in the Gulf Coastal Plain in that there is a basement composed of relatively old, well consolidated rocks unconformably overlain by strata of

unconsolidated material (Klein et al., 1950). A geologic cross section of the Study Area is presented in Figure II-5. These consolidated rocks of Paleozoic age are estimated to lie 4,600 feet below sea level in the extreme southeastern section of Jefferson County (Spooner, 1935). This axial downwarping leads to the Desha Basin, an asymmetrical basin whose deepest development can be noted in Desha, Lincoln and extreme southeastern Jefferson counties. The various geological eras are treated in Appendix A.

3. Unusual Geologic Features.

a. Hills and Bluffs.

A series of Jacksonian outcrops and alluvial terrace deposits appear as bluffs along the Arkansas River floodplain (Figure II-3). These bluffs form the westernmost limits of the Arkansas River floodplain. In the Study Area they include Tripletts Bluff, Yellow Bluff and Pine Bluff. Tripletts and Yellow bluffs are located within the Pine Bluff Arsenal and are composed of Jacksonian deposits overlain by Pleistocene alluvial terrace deposits.

(1) Tripletts Bluff.

Tripletts Bluff forms the west bank of the Arkansas River for 0.7 miles (1.1 km) of its total length of about 1.5 miles (2.4 km), averaging 30-40 feet (9.2-12.2 m) above the mean height of the Arkansas River. While usage is generally classified by the U.S. Army, some portions of the bluff are used for yearly youth outings. Mixed-age pine stands are found in the areas of the bluff which were previously cleared. Slumping of soil into the Arkansas River occurs quite regularly along Tripletts Bluff due to the erosional activities of the river.

(2) Yellow Bluff.

Yellow Bluff adjoins Yellow Lake and its associated lowlands to the south of Tripletts Bluff. It overlooks the floodplain from elevations of 20-30 feet (6.1-9.2 m) along its approximate 1.8 mile (3.0 km) course. Its usage is similar to that of Tripletts Bluff.

(3) Pine Bluff.

The remains of this distinctive bluff can be found on the east bank of Brumps Bayou in the area of the bayou's confluence with Lake Pine Bluff (Figure II-3). After initial settlement by Joseph Bonne, the bluff area proliferated; however, erosion from the Arkansas River gradually eliminated almost the entire settlement. A portion of the bluff area is now covered by Lake Pine Bluff.

(4) Hills.

The western portion of the Study Area is composed of gently rolling hills, with elevations greater than 350 feet msl. These hills are composed of two different geologic depositions, the Jacksonian Stage and Pleistocene terrace deposits overlying Jacksonian deposits. Jacksonian sediments in these areas are lignitic, while Pleistocene deposits in these hills contain a mixture of sand, gravel and clays.

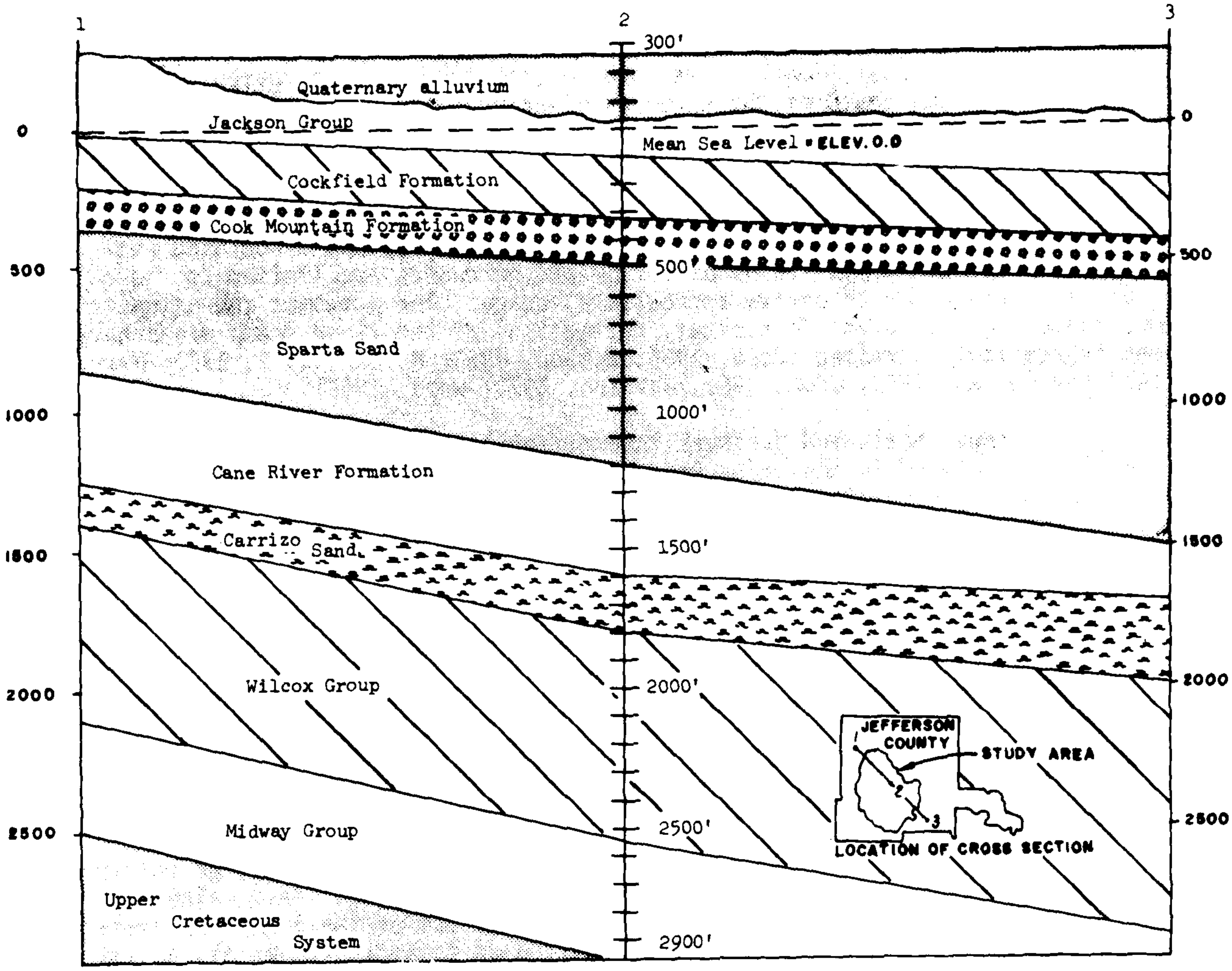



FIGURE II-5: GEOLOGIC CROSS SECTION OF STUDY AREA

Sources: Klein et al., 1950; Caplan, 1954; Hosman et al., 1968.

b. Riverine Features.

Bayou Bartholomew, southeast of Pine Bluff, is believed to occupy a portion of an old Arkansas River channel and constitutes a unique geological feature. Other major streams south of the Arkansas River probably occupy old channels of that river (Holder, 1971).

The Arkansas River floodplain contains a number of oxbow lakes, backwater areas and natural levees (Figure II-10). Water from the oxbow lakes is used for both irrigation and recreation. Backwater areas and associated wetlands which feature dense stands of bottomland hardwoods are limited to those areas not drained for intensive agricultural usage. The economic and esthetic importances (i.e., wildlife habitat, recreation) of the river swamp areas have been increasingly stressed (Cope, 1966; Durand, 1963; Holder, 1971, 1972; Martinez and Durham, 1969; Odum, 1969; Wharton, 1970; Wood, 1955).

Various shoals and sandbars intermittently dot the course of the Arkansas River included in the Study Area. These sandbars can be quickly deposited or eroded during high river stages, as currents laden with silt and fine sands either deposit their loads in the more quiet waters opposite river bends or erode the depositions through changing currents.

Two "islands" are situated in the Arkansas River, although the term "island" does not apply during low river stages when these bodies may become connected to land. Hensley Point was formed after alluvium was cut into and isolated from adjoining land by shifting river channels. Boyd Point was created in the early 1960's after excavation of the Boyd Point Cutoff and subsequent diversion of the Arkansas River channel isolated this body from adjacent land. Boyd Point should be termed a peninsula, as a permanent levee connects this land body with the mainland (Figure II-10).

Hensley Point consists of approximately 350 acres (142 ha.) of poorly to moderately drained bottomland hardwoods and sandbar areas. This island has remained mostly in its natural state; no commercial use of the land has developed. Hensley Point has considerable value from an esthetic viewpoint, as its location adjacent to the river and its fauna and flora help make this a unique area for camping, birdwatching, swimming and other esthetic uses.

Boyd Point contains approximately 2,400 acres (972 ha.) of poorly to moderately drained land consisting of bottomland hardwoods, sandy beach areas, pastureland and a 165 acre (67 ha.) sewage lagoon operated by the City of Pine Bluff.

c. Fossil Evidence.

Although no classical zones of fossils are found in the Study Area, a locality for Jacksonian age fossils is found in the White Bluff area. It is the site of the best exposures of marine Jacksonian deposits in the Mississippi Embayment (Wilbert, 1953). Deposits here contain fossilized molluscs, brachiopods, foraminiferans and bryozoans indicative of near-shore marine and estuarine conditions. Nonmarine Jacksonian deposits are found throughout the remaining portion of the area; these deposits contain lignitic layers of fossilized plant materials.

4. Economic Geology.

Sand and gravel are the only mineral resources commercially obtained in the Study Area. Sand and gravel operations are located either in the western and southwestern county uplands or in the Arkansas River (Figure II-3). Sand and gravel excavated by front-end loaders in the uplands are generally used for road construction, while sand and fine gravel dredged by suction in the Arkansas River are used for building and construction (Stroud et al., 1969). Over two million tons of sand and gravel were taken in Jefferson County excavations between 1952 and 1966 (Stroud et al., 1969). The value of 1970 sand and gravel production was $317,000 in Jefferson County (U.S. Bureau of Mines, 1971). No other commercially important minerals are known in or have economic potential in the Study Area.

5. Springs.

Several noted spring areas (Figure II- 3) are found in the vicinity of Sulphur Springs in the southwestern portion of the Study Area. For many years water from this area was sold locally and the medicinal value of bathing in the springs was extolled. These springs are no longer used for these purposes. There are also a number of springs in the hilly westernmost areas of the Study Area.

6. Geologic Hazards.

No evidence of major faulting has been observed in the Study Area. However, Fisk (1944) concluded that both northwest-southeast and northeast-southwest trending faults are found throughout the entire Gulf Coastal Plain in a fracture-pattern. Figure II-3 delineates the approximate area of the fracture zone's closest proximity to the Study Area. Caplan (1954) suggested that faulting similar to that occurring in the exposed Paleozoic rocks in the Frontal Ouachitas of the Interior Highlands might be expected to occur southeastward well into the embayment areas. Such faulting in the Study Area could then possibly occur under 2,000-4,000 feet of Tertiary and Quaternary sediments. Little evidence of this can be found in the embayment, as faulting is generally obscured in the Study Area by the presence of thick unconsolidated post-Paleozoic sediments.

The "Fall Line" which crosses the state diagonally from southwest to northeast suggests the existence of a fault-line scarp in the Paleozoic outcrops 18 miles northwest of the Study Area. No evidence as yet has been obtained from available subsurface data. Geologic activity in that area could affect the Study Area's use of the Claiborne aquifers, as this formation outcrops in the parallel line southeast of the "Fall Line."

Evidence of slumping in the Study Area is minimal, as differential compaction of the unconsolidated Quaternary and Tertiary sediments tends to mute this. Areas adjacent to vertical excavations and road cuts occasionally slough off the banks. An example of this is the slumping of the bluffs adjacent to the Arkansas River in the northern portion of the Study Area. Faulting and slumping could be expected northeast of the Study Area in those sections of the embayment affected by the New Madrid, Missouri, earthquake of 1811-12. Areal placement of this fault system has not been made, however, and its affects on the subsurface geology in the Study Area are unknown.

7. Summary of Geologic Resources and Their Influence on the Study Area.

The surface and subsurface geologic resources principally play a subtle and indirect role in molding the characteristics of the Pine Bluff Study Area. Except for a small amount of sand and gravel operations, the geology of the area has contributed little to the direct economic base of the Study Area. Similarly, there is little in the way of distinctive geologic features and formations that are unique to the Study Area. Also, structural geologic hazards in the Study Area have played and will continue to play an insignificant role for the growth and development of Pine Bluff. As indicated elsewhere, Pine Bluff is located in a low seismic risk zone.

The most critical relationship of geology to the Study Area is expressed topographic relief. Of key significance is the location of Pine Bluff essentially on the escarpment between the gently rolling coastal plain to the west, the flat alluvial plain to the east, and the dominance of riverine-sculptured features. This setting has provided Pine Bluff with a diversity of environmental resources, a diversity in economic base and a diversity in its social characteristics. The setting has also been the key determinant in the patterns of growth and development of the Study Area and will continue to do so. The major topographic dichotomy in the area has resulted in many of the current problems (drainage, flood control and land use) which face the City of Pine Bluff.

Environmentally, the narrow, braided streams and the stands of mixed hardwoods and pines on the gently rolling uplands provide an array of habitats for species more commonly associated with the western portions of the State. To the east, the flat alluvial plain with its broad meandering rivers, numerous oxbow lakes and stands of bottomland hardwoods and semi-swamps provide habitat for lowland species characteristic of the Mississippi Delta system. In close association with the diversity of environs, is a variety of recreational opportunities and opportunities for the scientific study of natural history within the Pine Bluff Study Area.

Historically, the rich alluvial plain gave the Study Area its first economic footing, that of agriculture (principally cotton). Around this base developed much of the early social characteristics of the Study Area, which in large part, still remains today. With the development of the community, industries associated with timber, paper products and other wood products also developed in response to the abundance of land to the west to support stands of managed pine. Therefore, the area is basically economically inclined toward its natural land resources, being essentially split between agriculture and forestry.

The physical development of the City of Pine Bluff and the surrounding communities has also followed the topographic patterns. Much of the early development was located on the high grounds adjacent to the escarpment and in close proximity to both the alluvial plain and uplands. As the community developed, it spread both westward and eastward. In the latter direction, limitations to development were quickly encountered in the form of poor drainage and chronic flooding. The same limitations persist within the Study Area today, and future growth and development are merely projected through the southwest and western sections of the area.

C. SOIL RESOURCES.

1. General.

Maximum utilization of different land areas, whether for urban expansion or agricultural development, is dependent upon soils suitable for the intended use. Soil characteristics such as drainage, permeability, slope, erosion potential and location of various soil series and types are only a few of the soil features that should be considered when planning the direction and intensity of urban expansion or the agricultural productivity of an area. This section and Appendix A point out these and many other physical soil features necessary for establishing proper land-use suitability of Jefferson County soils. Wildlife suitability and potential productivity of soils for woodlands and agricultural crops are also included.

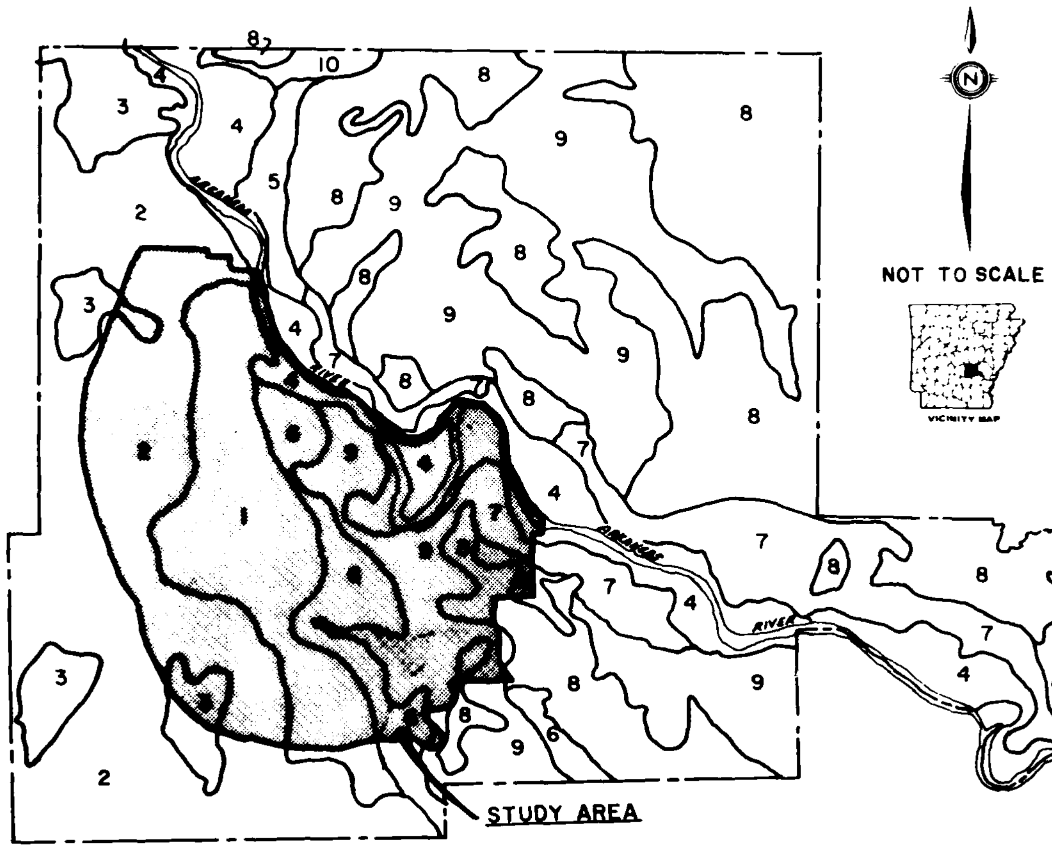
Soil resources were primarily prepared for agricultural purposes. The study and mapping of soils were limited to surface and near surface soils. This has serious limitations for engineering interpretation and physical characteristics of soils at depth. It should be emphasized that, for construction or land development purposes, these engineering interpretations are very general in nature and are intended only to point out problems which may be encountered. Limitations to future land use and development, such as structures or engineering works involving heavy loads or deep excavations, cannot be based on this type of data.

Soils in Jefferson County have been a result of sediment accumulation from repeated flooding by the Arkansas and Mississippi rivers. Extensive levee construction, particularly along these two large streams since 1927 has, however, reduced the buildup of alluvial deposits.

A general soils map of Jefferson County is shown in Figure II-6 which delineates the soil associations found in Jefferson County. Some mapping units are composed of different series or of different phases within a series. Jefferson County has two mapping units composed of different soil series, soil associations and soil complexes. Soil complexes differ from soil associations primarily by the distribution of the dominant soils. Whereas a soil association consists of a grouping of adjacent soils which can be delineated separately on a soil map, a soil complex consists of two or more soils so intermixed that they cannot be shown separately. Jefferson County has ten soil associations but only one soil complex. Jefferson County soils are categorized into three groupings in order that specific interpretations may be provided to land planners and users. The following categories are represented in this county: 1)soil associations, 2)soil series and 3)soil phases.

a. Soil Associations.

A soil association is made up of adjacent soils which are large enough to be shown individually on a detailed soil map, but are shown as one unit because the time and effort of describing them separately cannot be justified for broad scope planning purposes (Catlett, 1973). There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, however, the soils may differ greatly from one another.




LEGEND

1. Amy-Pheba-Savannah Association
2. Sawyer-Sacul-Savannah Association
3. Smithdale-Savannah Association
4. Crevasse-Portland Association
5. Desha-Latanier Association
6. Henry-Calloway-Grenada Association
7. Morganfield-Coushatta-Rilla Association
8. Perry-Portland Association
9. Rilla-Lonoke-Hebert Association
10. Rilla-McKamie Association

FIGURE II-6: GENERALIZED SOILS MAP FOR JEFFERSON COUNTY, ARKANSAS

Source: U.S. Department of Agriculture, 1971.

Soil associations for Jefferson County are presented in Figure II-6 and those for the Study Area are further described in Appendix A. This figure is useful for obtaining an overall idea of the characteristics of soils in the county. It serves as a valuable guide in the managment of large tracts of land such as watersheds, wildlife areas or forests. It is not suitable, however, for determining the intensive use and management of smaller areas such as subdivisions, farms, or fields.

b. Soil Series.

A soil series is made up of soil types and phases that have similar profile developments. Except for different textures in the surface layer which denote soil type, all the soils of one series have major horizons that are similar in thickness, arrangement and other important characteristics (Larance et al., 1973). All of the soils in the United States having the same series name are nearly alike in those characteristics that affect their natural behavior and treatment under most common uses (Cloutier and Fingers, 1966).

c. Soil Phases.

Soil phases are subdivisions of soil series and types. These divisions are based on differences in texture of the surface soil, slope, stoniness or some other characteristic that affects use of the soil by man (Catlett, 1973).

2. Summary and Relationships of Soil Resources to the Study Area.

Throughout most of the Study Area the slow percolation rates and seasonally high water tables of the soils allow flood waters, particularly in the eastern portions, to be retained and prevent the operation of effective and efficient septic tank leaching fields. The soils are well suited for the creation of artificial ponds and sewage lagoons. The soils in the western half of the Study Area on the coastal plain are generally poorly suited for dwellings or highways because of a high water table and low-bearing strength. Those to the east improve in their ability to support structures, but with higher flood potential in the eastern portion, these stable characteristics are difficult to utilize. Parodoxically, while hampering both urbanization and agricultural activity, these soil characteristics are responsible, in large part, for the high biological productivity of the alluvial plain in the past, and on a more limited scale of its high productivity today. With poor drainage, bottomland hardwood forests developed throughout the alluvial plain and with the retention of flood and rain waters, particularly in the spring, numerous habitats were created that support aquatic-oriented life. To the west, as rolling topography increases and drainage is improved, the low percolation rates of the soil play a much diminished role in the sculpturing of the biological community.

The combination of low percolation rates and seasonally high water tables throughout the area has created unfavorable conditions for septic tanks as a mechanism for the disposal of sanitary wastes. The inefficient septic tank leaching fields have had negative effects on the water quality of the Study Area. In addition, poor soil permeability and high annual water tables create a problem of infiltration and inflow into the existing sanitary sewage system which further compounds the problems of water quality in response to sanitary wastes disposal. Predictably, wherever urban development is serviced primarily by septic tanks, such as along the eastern and western fringes of the Pine Bluff city limits, there is a concomitant degradation of water quality: high fecal coliform bacteria levels, nutrient enrichment and relatively high organic loads. This is most markedly demonstrated by the water quality of Outlet Canal as monitored at Station 4. Slow percolation of flood waters and the waters of heavy rains, results in degraded water quality causing more runoff waters and their entrained waste load to be transported to the receiving stream. In summary, the role of soil in absorbing excess water and in filtering and purifying waters is a minimal role of the soils of the Pine Bluff Study Area.

As a determinant of growth, development and land use in the Study Area, soil characteristics are probably overshadowed by the characteristics of drainage. Although the soils to the west are relatively poor for foundations, the growth of Pine Bluff is predominantly to the west and southwest in response to the well developed drainage patterns of the uplands. To the east, the soil characteristics are favorable for growth and development, but severe flooding on the flat alluvial plain is the key determinant of growth.

The majority of the soils in the Study Area are suitable for agricultural purposes, from managed pine to the west, to cotton, soybeans and rice to the east. Because of this, the soils have played a key role in determining the economic growth of the Study Area and will continue to do so in the future.

## D. HYDROLOGIC RESOURCES.

The hydrologic resources section is concerned with the climatology, surface and ground water, the use of these waters and the future hydrologic conditions of the Study Area. Climatology of the Study Area will be discussed in terms of temperature, precipitation, humidity, winds, evapotranspiration and climatic hazards. In the description of the surface water conditions, discussions on watersheds, drainage basins, water bodies, commercial navigation and streamflow will be presented. Existing aquifer systems will be covered in the ground water section. Water utilization for both surface and ground water will be discussed, along with projections of future hydrologic conditions. Surface and ground water quality are discussed in Section IV.

### 1. Climatology.

Geographically, Arkansas is divided into two principal divisions. These divisions fall on either side of a line that bisects the State from the northeast to the southwest. To the west and north of this line are the interior

highlands and to the east and south are the lowlands. To a lesser extent, the climate of Arkansas is also delineated by this imaginary diagonal line. The Ozark and Boston Mountain ranges are the most influential topographical features that effect Arkansas weather. Climatic differences between these areas, however, are not as great as the topographical differences of the two areas. The northwestern segment of Arkansas is generally cooler, with greater temperature extremes; humidities are lower and there is less cloudiness. The decreased humidities and cloudiness are caused by the increased distance from the moisture source of the Gulf of Mexico. Temperature extremes show little variation throughout the State. Winter temperatures vary more noticeably from northwest to southeast than is the case in the summer. The winters are short, but cold periods of brief duration do occur. Rainfall is normally abundant and well distributed throughout the year. Precipitation in Arkansas is usually of the shower type, with the exception of general rain periods occasionally occurring in the late fall, winter and early spring months. However, extended drought periods, as well as occasional flooding by local storms, are not unusual. Precipitation amounts are influenced by both local orographic and geographic features within the State. Even though most of Arkansas's precipitation is in the form of rain, snow occurs in the northwestern portion of the State. Snowfall also occurs in the southeastern portion of the State, however, it is generally light and usually remains on the ground briefly (U.S. Department of Commerce, 1969).

Records utilized in the preparation of this section were obtained from the National Weather Service (formerly the U.S. Weather Bureau) Asheville, North Carolina. Data was also obtained from the Pine Bluff Weather Station.

a. Temperature.

Records from the Pine Bluff Weather Station were used to establish normals for the Study Area. The temperature normals for the Study Area are presented in Table II-1. These temperature normals range from a low of 44.2° F in January to a high of 83.0° F in July. The average annual temperature is 64.2° F (U.S. Department of Commerce, 1973). The recorded temperature extremes for Pine Bluff are 112° F for the highest and -6° F for the lowest (U.S. Department of Commerce, 1965).

b. Precipitation.

Precipitation normals are presented in Table II-2. Rainfall is usually well distributed throughout the year, although sudden heavy rain and short drought periods are not uncommon. The average number of days receiving measurable precipitation is around 100 days (U.S. Department of Commerce, 1969), resulting in an average annual precipitation of approximately 50 inches (U.S. Department of Commerce, 1973). Winter and spring are generally the wettest times of the year, with rainfall averaging between four and six inches per month. The driest time of the year is usually in the fall when average monthly precipitation totals seldom exceed 3.5 inches. Although precipitation falls principally as rain, snowfall averaging a little over 12 inches occurs in the higher elevations of the Ozarks in the northwestern portion of the State. Snowfall in the southeastern counties, however, is only about one to two inches, with many winters receiving no snowfall (U.S. Department of Commerce, 1969). Rainfall frequency values are shown in Table II-3. The data for Table II-3 was obtained from the isopluvial maps constructed by the National Weather Service. The mean annual precipitation is displayed as four inch isohyets on Figure II-7.

Table II-1

Monthly and Annual Temperature Normals
for the Study Area

(Degrees)

| STATION | MONTH | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. | ANNUAL |
| Pine Bluff | 44.2 | 47.6 | 54.3 | 65.2 | 72.4 | 79.7 | 83.0 | 82.3 | 75.7 | 65.5 | 54.1 | 46.1 | 64.2 |

Source: U.S. Department of Commerce, 1973.

Table II-2

Monthly and Annual Precipitation Normals
for the Study Area

(Inches)

| STATION | MONTH | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. | ANNUAL |
| Pine Bluff | 4.47 | 4.79 | 5.41 | 5.65 | 5.51 | 2.85 | 3.57 | 3.14 | 3.60 | 3.23 | 4.00 | 4.50 | 50.72 |

Source: U.S. Department of Commerce, 1973.

Table II-3
Rainfall Frequency near Centroid of Study Area
(Inches)

| FREQUENCY | 30-minutes | 1-hour | 2-hours | 3-hours | 6-hours | 12-hours | 24-hours |
|---|---|---|---|---|---|---|---|
| 1-year | 1.28 | 1.58 | 1.89 | 2.12 | 2.58 | 3.10 | 3.63 |
| 2-years | 1.46 | 1.82 | 2.29 | 2.49 | 3.00 | 3.63 | 4.22 |
| 5-years | 1.83 | 2.30 | 2.81 | 3.17 | 3.77 | 4.71 | 5.27 |
| 10-years | 2.08 | 2.67 | 3.25 | 3.63 | 4.31 | 5.25 | 6.23 |
| 25-years | 2.39 | 3.00 | 3.75 | 4.15 | 5.01 | 6.05 | 7.01 |
| 50-years | 2.62 | 3.39 | 4.19 | 4.62 | 5.61 | 6.71 | 7.82 |
| 100-years | 2.93 | 3.71 | 4.57 | 5.08 | 6.12 | 7.53 | 8.56 |

Source: U.S. Department of Commerce, 1963.

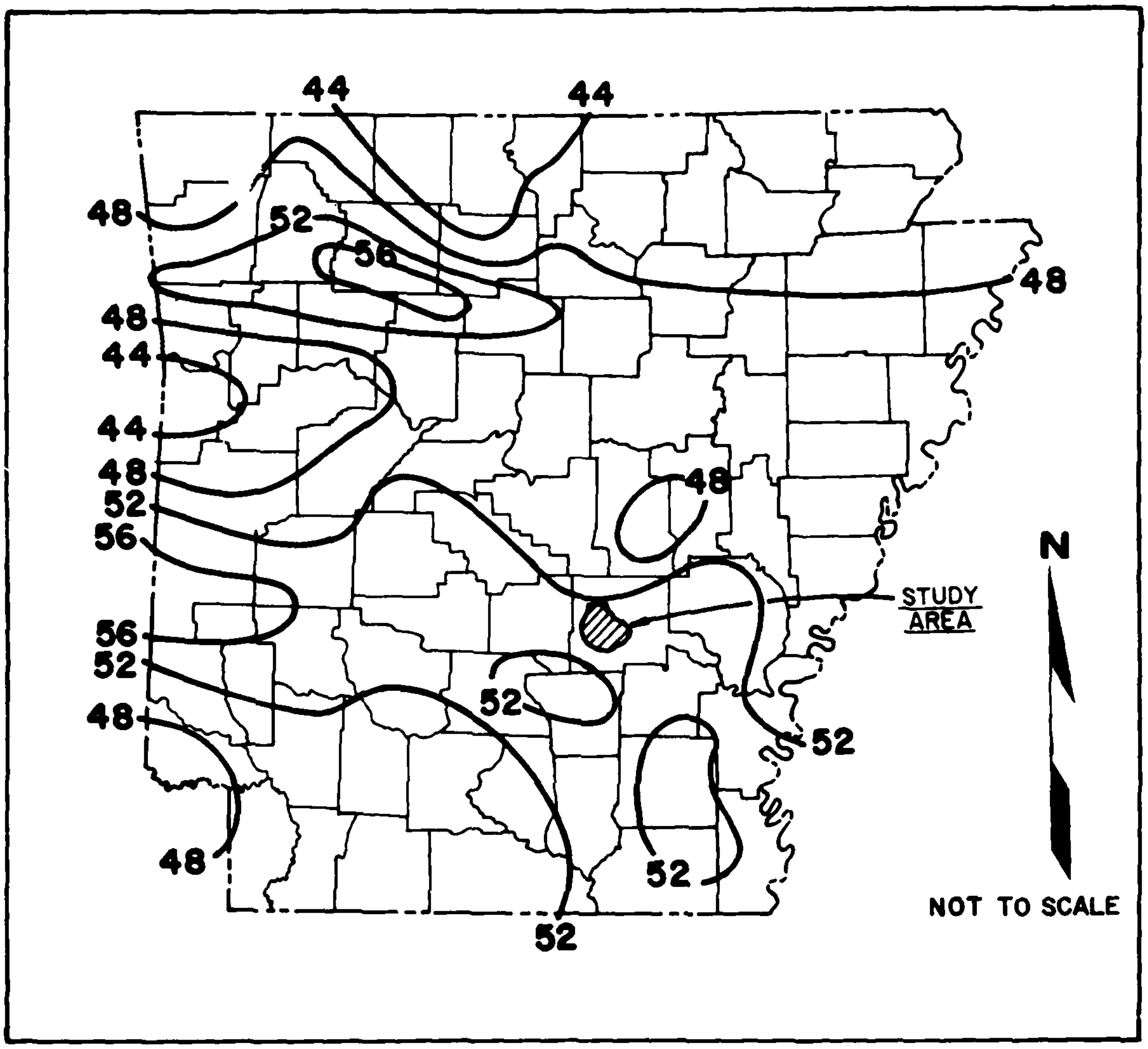



FIGURE II-7: MEAN ANNUAL PRECIPITATION FOR ARKANSAS
(CONTOUR LINES INDICATE INCHES PER YEAR)

Source: U.S. Department of Commerce, 1969.

c. Wind.

Seasonal wind roses for Pine Bluff are presented in Figure II-8. The data used are observations of wind speed and direction taken once per hour during the years 1948 through 1954. The mean scalar wind speed for each direction and the percentage of the total observation showing calms (speed less than 0.5 knots) are indicated.

d. Evaporation.

Evaporation is the process by which water is transformed from the liquid state to the gaseous vapor state. Natural evaporation from the numerous water bodies found in the Study Area is strongly affected by temperature, humidity and wind. High temperatures have a pronounced effect on the evaporation rate. Measurements of evaporation are made utilizing evaporation pans. The Study Area has a pan evaporation of approximately 58 inches. Lake evaporation in the Study Area is about 43 inches. Studies have shown that pan evaporation exceeds natural evaporation of larger water bodies. Coefficients have been developed relating pan to lake evaporation and, in the Study Area, it is 0.75 (U.S. Department of Commerce, 1959).

e. Climatic Hazards.

Severe weather consists primarily of tornados and hailstorms, although tropical storms do penetrate into the southeast and southwestern sections of the State. One should take caution in interpreting severe weather information, since there is a direct relationship between location of first order Weather Bureau stations and the number of tornado sightings.

(1) Tornados.

Tornados' frequencies tend to be much greater in the northern one-third to two-thirds of the State (Reinhold, 1968). Fewest tornadoes occur in the south-central counties and in a small area near the Ozarks and Ouachita Mountains (Reinhold, 1968). Since 1953, when the U.S. Weather Bureau initiated its tornado forecasting effort, Arkansas has ranked 13th in the nation in tornado frequency, with an annual average occurrence of over 17 per year (U.S. Department of Commerce, 1969). The monthly frequency of tornados is shifted about 30 days earlier than the national pattern (Reinhold, 1968). As a result of this shift, March, April and May are the principal months for tornado occurrence, with a sharp decrease the following month. Figure II-9 presents initial points of ground contact of verified tornados during the years 1951 through 1970.

(2) Hailstorms.

Hailstorms, although less severe than tornados, do occasionally cause considerable damage to agriculture. Hailstorms are fairly uniformly distributed throughout the State. Seasonal distribution indicates April to be the principal month for hailstorm occurrence based on storms with hail of 3/4 inch (1.9 cm) or larger.

(3) Windstorms.

Windstorms are created primarily by squall lines and are predominant in central and east-central Arkansas with occasional occurrences in the northeast counties. April tends to be the most windy month (Reinhold, 1968).

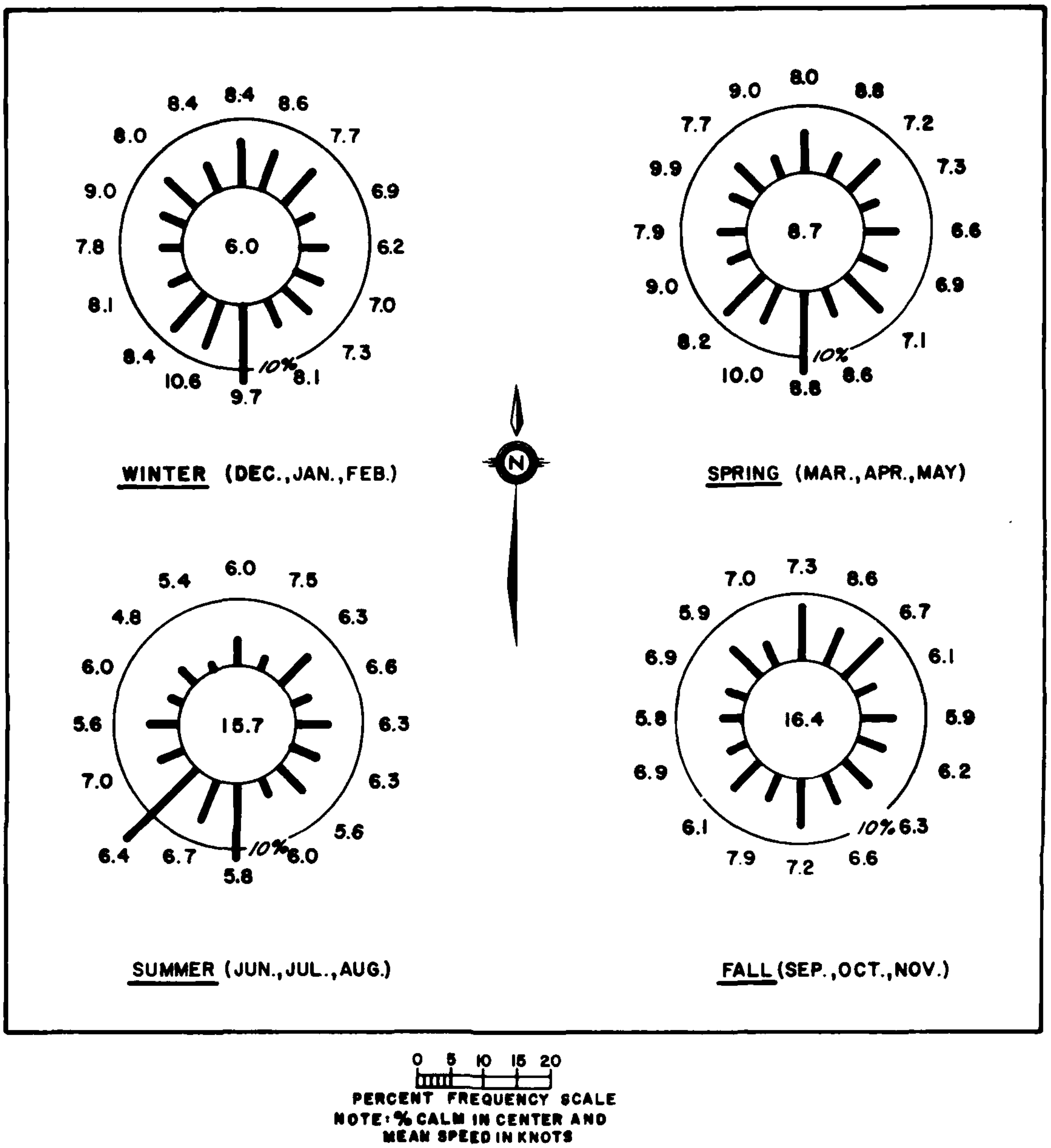



FIGURE II-8: SEASONAL WIND ROSES, PINE BLUFF, ARKANSAS, 1948-1954

Source: U.S. Air Force, 1968.

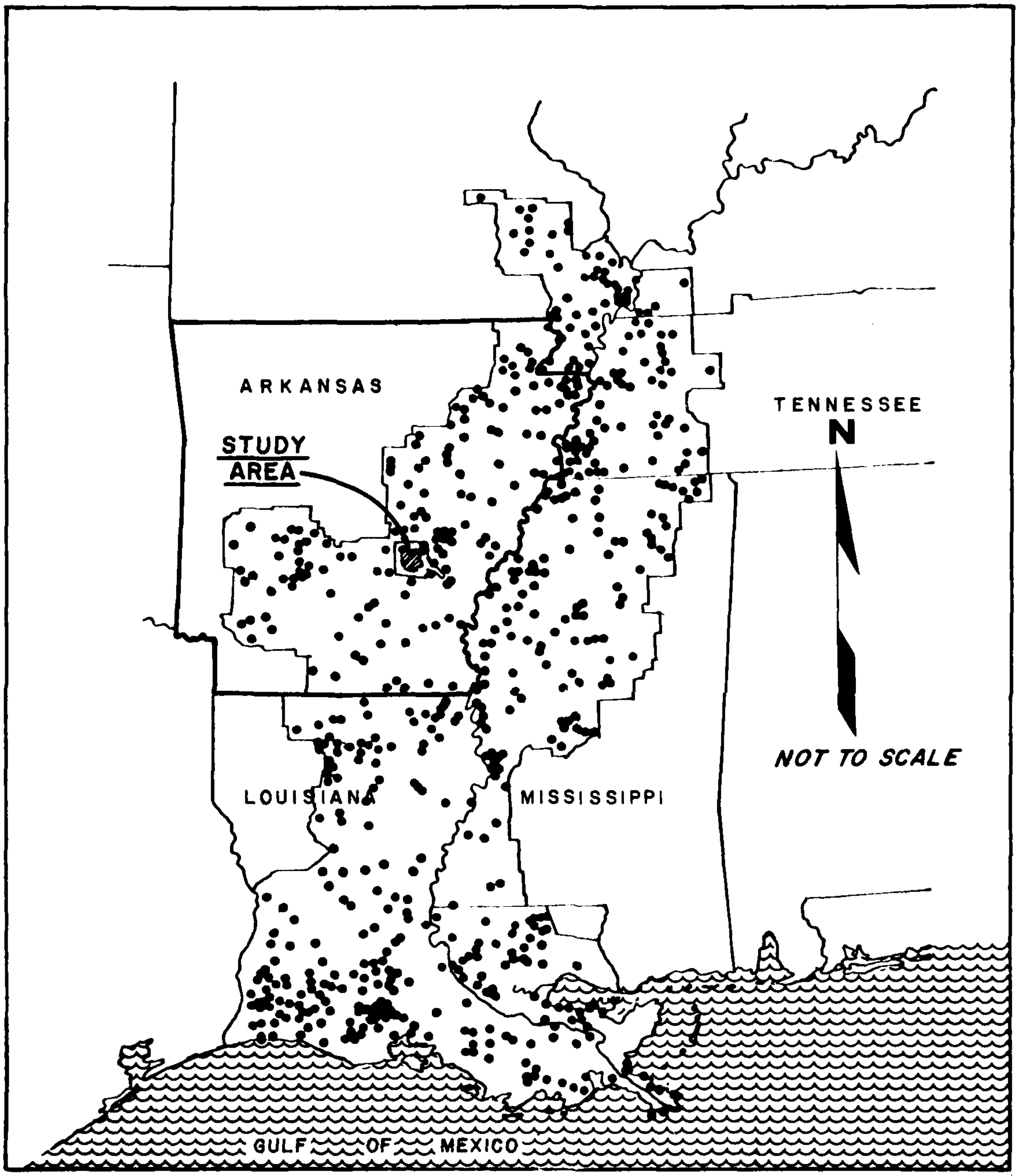



FIGURE II-9: INITIAL POINTS OF GROUND CONTACT OF 624 VERIFIED TORNADOES IN COUNTIES MAKING UP THE LOWER MISSISSIPPI REGION DURING THE YEARS 1951-1970

Source: U.S. Army Corps of Engineers, 1974c.

(4) Lightning.

Lightning deaths are most prevalent during the summer months. This may be due to the increase in outdoor activities during the warmer months. Arkansas statistics from October, 1958 through September, 1968, however, indicate tornados to be the primary killer rather than lightning (Reinhold, 1968).

(5) Flooding.

Flood protection in the Study Area has been increased over the past few years, however, flooding is still a major concern. An extensive levee system runs along the south bank of the Arkansas River and in conjunction with numerous upstream flood control projects, it greatly reduces the probability of major flooding from the Arkansas River. Several streams in the area, particularly Bayou Bartholomew, are still of major concern because damaging floods on the bayou in the vicinity of the City of Pine Bluff occur two or three times a year. Significant damages from these floods occur every three to five years.

Local flooding due to poorly developed runoff patterns occurs at many locations within the Study Area. Periods of intense rains cause flash flooding because of an inadequate storm water drainage system within the City of Pine Bluff. These susceptible areas are scattered throughout the City. This flooding due to inadequate drainage also occurs along streams and ditches such as Bayou Bartholomew, Brumps Bayou, Harding Drain, Town Branch, Outlet Canal and Interceptor Canal and, in the recent past, has resulted in the loss of life.

f. Summary and Relationships ~~of~~ Climate to the Study Area.

Climate of the Study Area is mild. The summers are long and hot, and the winters short and moderate. Precipitation is abundant throughout the year, with the heaviest rainfall periods occurring in the winter and early spring. The transportation and storage of atmospheric moisture plays a significant role in the hydrologic cycle. Rainfall in the Study Area serves to help restock ground water aquifers thereby furnishing water supplies to industry and municipalities, and provides water for agriculture irrigation, vegetation, and streams, lakes and ponds (which are ultimately used for recreation purposes) and support of aquatic biota.

The long growing season and the abundance of moisture allows the Study Area to be productive both in agriculture and the development of its forest communities. The climatic regime is also significant in the Study Area's biological resources. Not only does the abundance of moisture and moderate climate provide favorable habitat for a variety of species, but the mildness of its winters also creates favorable winter habitat for many migrating bird species. Important too, the long hot summers can create a water shortage, particularly in the upper reaches of Bayou Bartholomew and in many of the small rivers, ponds and lakes which dot the area. Thus, biological communities dependent upon shallow waters and pools become particularly fragile and sensitive to erradication during the warmer months. The same phenomena is also responsible for alteration of water quality. During the long hot summer months, flows are often reduced markedly, dissolved oxygen levels decrease, and the overall assimilative capacity of the stream diminishes. During these months, discharges from both point and non-point sources have a more significant impact to the overall water quality of the stream. In turn, the biological communities dependent upon

quality waters suffer, and alter appreciably during the summer months. They become more fragile than one would anticipate from an overall perspective of the Study Area's climate.

Human activity is impacted by the long summers as well. In agriculture, irrigation waters from shallow wells or from more permanent stream sources must be tapped to maintain high agricultural yields. Generally too, the summer months are unpleasant and to some degree limit the esthetic and recreational potential of the area.

The abundance of water, particularly during the early spring and during frequent heavy rain storms, creates chronic problems in flooding and drainage. This is particularly pronounced on the alluvial plain where the topography is flat and the meandering streams frequently overflow their banks. In the eastern portions of Pine Bluff, streets flood and transportation is hampered.

While flooding is generally beneficial to an aquatic-oriented biological community because it introduces nutrients and creates extensive backwater areas and accumulates rubble and debris, which will serve as potential habitats, it can also accord a certain instability to a stream system and, thereby, limit its biological potential. Many nesting bird species and the nest requirements for several species of reptiles and amphibians are adversely affected by severe flooding.

Heavy rains and flood waters also are potentially detrimental to water quality. This is manifested in several ways: first, within the urban areas the combination of heavy rains and impervious surfaces translates into increased volumes of water and increased volumes of entrained pollutants reaching the receiving stream. Also, within the urban areas, problems of septic tank overflows, overloading of the sanitary collection systems by infiltration and bypasses of pumping stations all combine to contribute sanitary waste materials to the receiving streams. These wastes are expressed as increased fecal bacteria counts, increased levels of nutrients and increased levels of organics.

Throughout the Study Area, wherever lands are cleared for development for agricultural purposes or forestry, heavy rains can potentially introduce large quantities of silt and sediment which can severely limit the biological productivity of the various water courses. Within agricultural areas, these silts and sediments flushed to the stream by heavy rains are often laden with a number of pesticides and their derivatives.

2. Surface Water Resources.

Jefferson County's abundant surface water serves as an important natural resource and provides a base for recreation, transport, livestock watering and irrigation. The proximity of lakes and streams and the extensive and productive aquifer systems allow the area to support a growing population and remain attractive for both agriculture and industry. The principal categories of usage include public supply, industry, irrigation, and a variety of rural, esthetic and recreation uses. Because water is the focal point for the study, this report endeavors to provide an in-depth assessment of both surface and ground water resources.

Because surface water quality is one of Pine Bluff's more important problems, surface water resources are discussed first, including delineation and

description of the two major drainage basins, along with each basins' accompanying sub-basins (Figure II-10). Major water bodies, including lakes, ponds, lagoons, wetlands, streams, rivers, channels and canals are covered, along with commercially navigable waterways. Runoff characteristics of the major drainage areas are also explored. Surface water quality is presented in Section IV.

a. Watershed Description.

(1) Drainage Basins.

The Study Area lies within the Gulf Coastal Plain physiographic region. The area is characterized by a gently undulating landscape, having a prevailing drainage pattern from the northwest to the southeast following the slope of the land. The Study Area straddles the boundary between the Arkansas River Basin to the north and the Ouachita River Basin to the south. The boundary of these two drainage basins transects the northern edge of the City of Pine Bluff, passing south of Lake Pine Bluff and extending southwestward to the western edge of the City where the boundary turns northwestward to the Study Area limits along the Monticello Ridge (Figure II-10). Each of these drainage basins are drained by several streams and associated tributaries (referred to hereafter as systems). These systems represent a complex tributary network of either the Arkansas or Ouachita rivers. The three systems recognized in the Arkansas River Basin are the Caney Bayou and its tributaries; tributaries to the Arkansas River and Lake Langhofer; and Brumps Bayou which includes Lake Pine Bluff. The Ouachita River Basin includes the Bayou Bartholomew and Deep Bayou systems. For each system, there are a number of sub-basins. Figure II-10 depicts the two major river basins, the systems that make up the basins, and the corresponding sub-basins. Tables II-4 and II-5 list all of the man-made and natural lakes, ponds and lagoons located within the Pine Bluff Metropolitan Study Area that are over five acres on the surface. They are all located on Figure II-10 by a map code number.

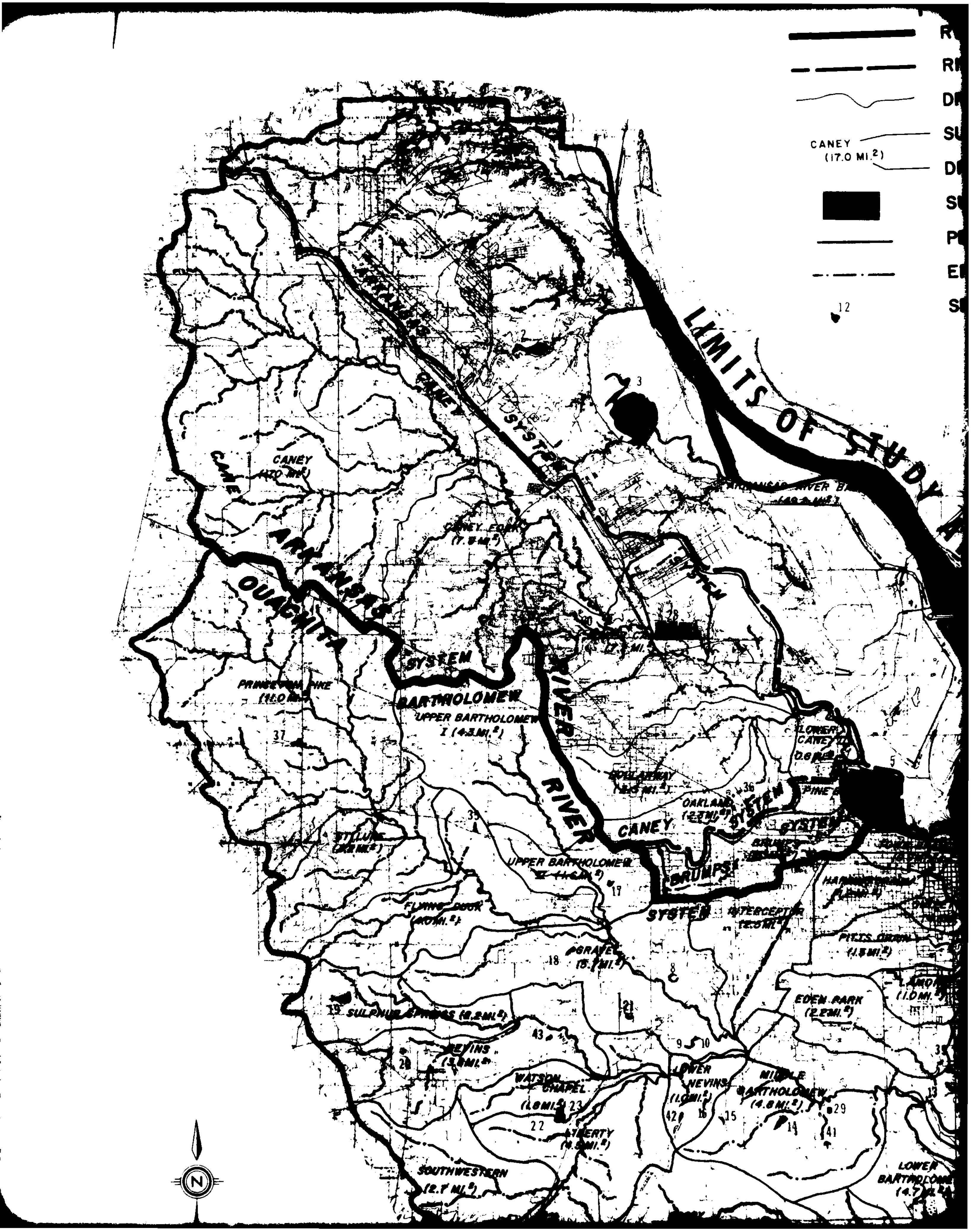
(a) The Arkansas River Basin.

The Arkansas River Basin extends from the eastern slopes of the Rocky Mountains in central and southeastern Colorado and northeastern New Mexico to the south-central portion of Kansas and the north-central part of Oklahoma, including the northern half of the Texas Panhandle. Entering Arkansas from the northwest, the Basin extends southeasterly to the Mississippi River. The total drainage area of the basin is 160,645 square miles (U.S. Army Corps of Engineers, 1973c).

Within the Study Area, the Arkansas River Basin covers 91 square miles of the northern portion of the Study Area. Table II-6 gives the systems, sub-basins, and square mileage for the Arkansas River Basin. A schematic of the Arkansas River Basin is presented in Figure II-11. This schematic graphically presents the major surface water features of this drainage basin showing major tributaries, channel lengths, and gaging stations. It should be noted that most streams in the Study Area begin as ephemeral streams.

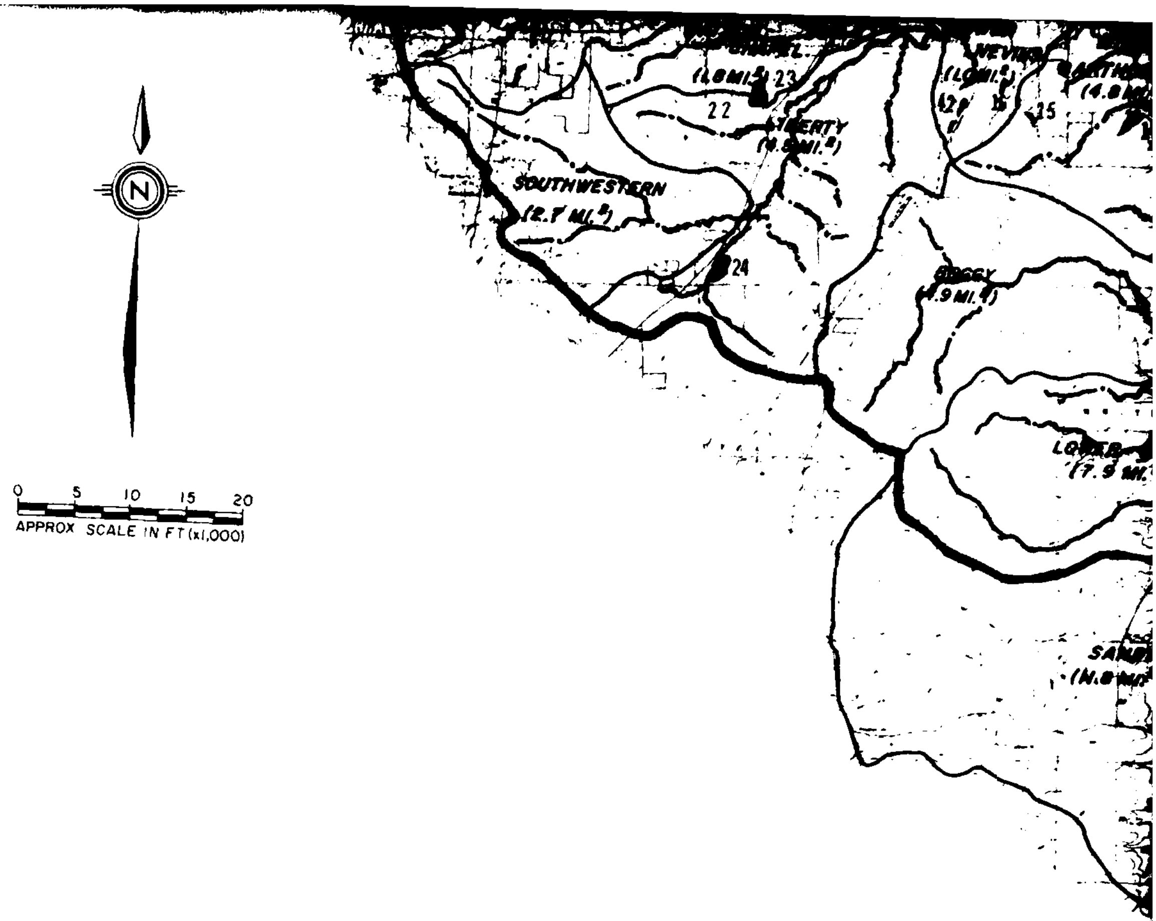
1. The Caney Bayou System.

Caney Bayou originates in the northwestern corner of the Study Area slong the eastern flank of the Monticello Ridge, approximately 15 miles from Pine Bluff. Flowing southeastward to Black Dog Lake and eventually


CANEY
(17.0 MI.²)
LIMITS OF STUDY
ARKANSAS RIVER
CANEY SYSTEM
OUACHITA RIVER SYSTEM
BARTHOLOMEW RIVER
CANEY
BRUMPS SYSTEM
CANEY FORK
(7.5 MI.²)
UPPER BARTHOLOMEW
I (4.3 MI.²)
UPPER BARTHOLOMEW
II
FLYING DUCK
SULPHUR SPRINGS
NEVINS
WATSON CHAPEL
LIBERTY
SOUTHWESTERN
(2.7 MI.²)
LOWER NEVINS
MIDDLE BARTHOLOMEW
(4.8 MI.²)
LOWER BARTHOLOMEW
EDEN PARK
(2.2 MI.²)
PITTS ORINN
INTERCEPTOR
LOWER CANEY
OAKLAND
PINE
N

## LEGEND

- RIVER BASIN BOUNDARY
- RIVER SYSTEM DRAINAGE BOUNDARY
- DRAINAGE SUB-BASIN BOUNDARY
- CANEY — SUB-BASIN NAME
- (17.0 MI.²) — DRAINAGE AREA
- SURFACE WATER
- PERMANENT STREAM
- EPHEMERAL STREAM
- 12 — SEE TABLES II-4 & II-5 FOR NUMBER CODE




# HYDROLOGIC RESOURCES & DRAINA
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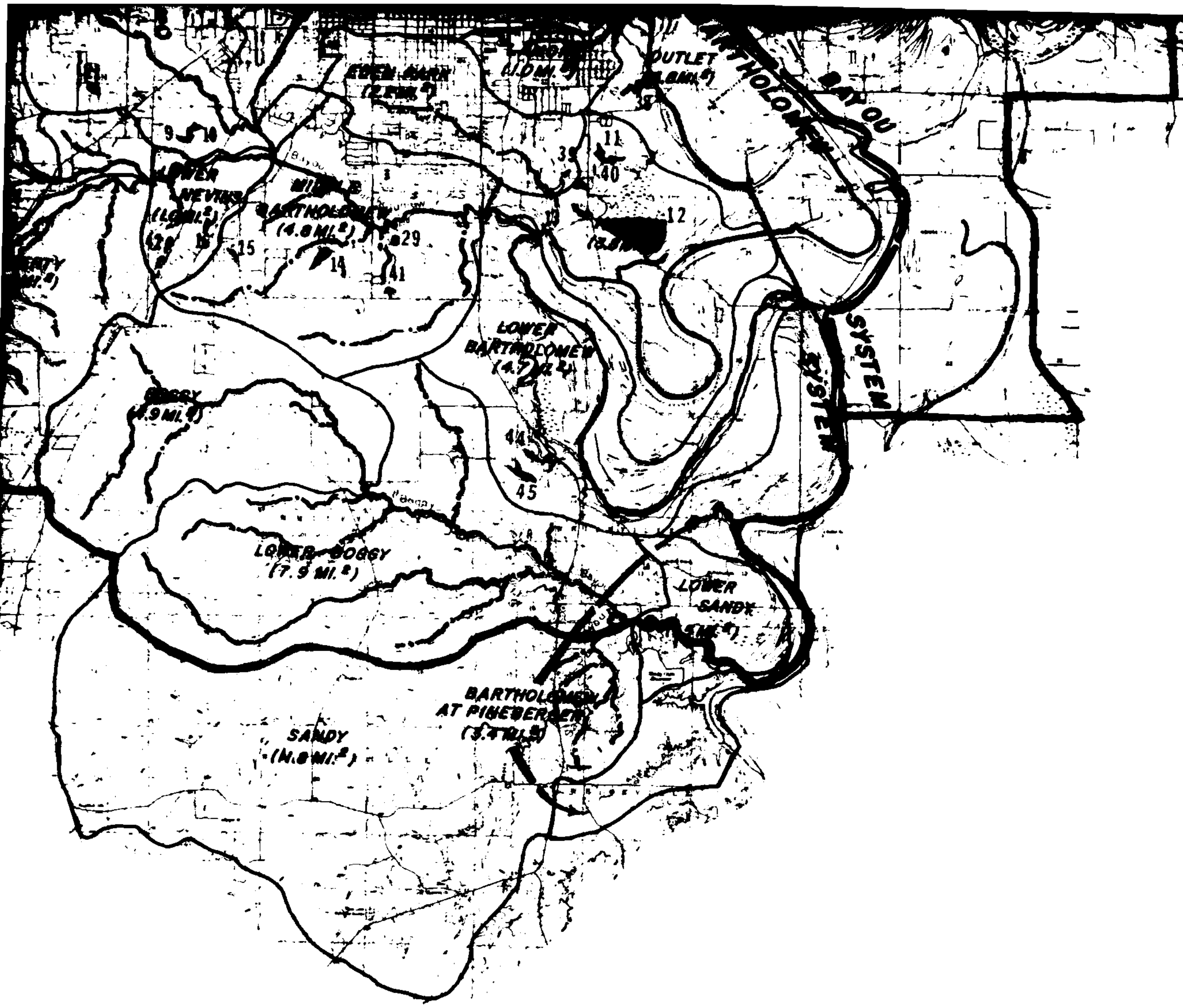



ES & DRAINAGE UNITS
F STUDY AREA

FIG. II-10

41

Table II-4
Man-Made Lakes, Ponds and Lagoons in the Pine Bluff Metropolitan Study Area of More Than Five Surface Acres
(see Figure II-10)

| MAP CODE | LOCATION | SURFACE AREA (ACRES) | CAPACITY (ACRE-FEET) | WATER USE | LOCAL NAME (WHERE APPLICABLE) |
|---|---|---|---|---|---|
| 1 | 16-T4S-R10W | 20 | 140 | R | |
| 2 | 28,33-T4S-R10W | 65 | 520 | R | Tulley Lake |
| 4 | 7,18-T5S-R9W | 25 | 250 | R-Ir-FC | |
| 5 | 29,32-T5S-R9W | 500 | 4,000 | R | Lake Pine Bluff |
| 6 | 19-T5S-R10W | 11 | 77 | R | |
| 7 | 20-T5S-R10W | 6 | 42 | R-L | |
| 8 | 18-T6S-R9W | 5 | 35 | R-L | |
| 9 | 19-T6S-R9W | 10 | 80 | R-L | |
| 10 | 19-T6S-R9W | 8 | 64 | R-L | |
| 12 | 26-T6S-R9W | 74 | 296 | C-Ir | |
| 13 | 27-T6S-R9W | 7 | 49 | R | |
| 14 | 29-T6S-R9W | 20 | 140 | R-L | |
| 15 | 30-T6S-R9W | 10 | 60 | R-L | |
| 16 | 30-T6S-R9W | 9 | 54 | R-L | |
| 17 | 12-T6S-R10W | 8 | 56 | R-L | |
| 18 | 14-T6S-R10W | 8 | 56 | R-L | |
| 19 | 17-T6S-R10W | 25 | 200 | R | Lake Taloha |
| 20 | 21-T6S-R10W | 5 | 40 | R | |
| 21 | 24-T6S-R10W | 7 | 42 | R | |
| 22 | 26-T6S-R10W | 9 | 63 | R | |
| 23 | 26-T6S-R10W | 7 | 49 | R | |
| 24 | 35-T6S-R10W | 10 | 70 | R | |
| 25 | 31-T5S-R8W | 127 | - | Aeration Lagoon | International Paper |
| 26 | 32-T5S-R8W | 100 | - | Activated Sludge Ponds | International Paper |
| 27 | 14,21,22,23-T5S-R10W | 330 | - | Oxidation Pond | Boyd Point |
| 28 | 14-T5S-R10W | 40 | - | Oxidation Pond | Caney |
| 29 | 28-T6S-R9W | 5 | - | Oxidation Pond | Indian Hill |
| 30 | 15-T5S-R10W | 14.7 | - | Oxidation Pond | Whitehall |
| 38 | 14,23-T6S-R9W | 18 | 126 | R-L | Taylor Lake |

Note: Explanation for Water Use abbreviations in tabulation:
R - Recreation
Ir - Irrigation
L - Livestock
FC - Flood Control
C - Commercial Fish Farm

Source: Soil Conservation Service, pers. comm.

Table II-5
Natural Lakes and Ponds in the Pine Bluff Metropolitan Study Area
of More Than Five Surface Acres
(see Figure II-10)

| MAP CODE | LOCATION | SURFACE AREA (ACRES) | CAPACITY (ACRES-FEET) | WATER USE | LOCAL NAME (WHERE APPLICABLE) |
|---|---|---|---|---|---|
| 3 | 34,35-T45-R10W | 400 | 1,600 | R | Yellow Lake |
| 11 | 23-T65-R9W | 16 | 80 | R | Byrd Lake |
| 31 | 2,3-T55-R10W | 7 | 49 | R | |
| 32 | 19-T5S-R8W | 7 | 35 | R | Bream Lake |
| 33 | 19-T5S-R8W | | | | |
| | 24-T5S-R9W | 50 | 350 | R | Wilkins Lake |
| 34 | 31,32,T5S-R8W | 100 | 400 | R-Ir | Johnson Lake |
| 35 | 32-T5S-R10W | 7 | 49 | R | |
| 36 | 36-T5S-R10W | 9 | 54 | R | |
| 37 | 25-T5S-R11W | 9 | 63 | R | |
| 39 | 22-T6S-R9W | 8 | 40 | R-L | |
| 40 | 23-T6S-R9W | 8 | 40 | R-L | |
| 41 | 28-T6S-R9W | 10 | 70 | R | |
| 42 | 30-T6S-R9W | 13 | 65 | R | |
| 43 | 23-T6S-R10W | 5 | 30 | R | |
| 44 | 3-T7S-R9W | 9 | 63 | R | |
| 45 | 3-T7S-R9W | 8 | 56 | R | |

Note: Explanation for Water Use abbreviations in tabulation:
R - Recreation
Ir - Irrigation
L - Livestock
FC - Flood Control
C - Commercial

Source: Soil Conservation Service, pers. comm.

Table II-6

The Arkansas River Basin, Systems and Sub-Basins Within the Study Area

| | |
|---|---|
| CANEY BAYOU SYSTEM (38.4 mi.$^2$) | - |
| Caney Sub-Basin | 17.0 |
| Caney Fork Sub-Basin | 7.8 |
| Lower Caney I Sub-Basin | 7.2 |
| Lower Caney II Sub-Basin | 0.8 |
| Dollarway Sub-Basin | 3.3 |
| Oakland Sub-Basin | 2.3 |
| ARKANSAS RIVER SYSTEM (49.2 mi.$^2$) | 49.2 |
| BRUMPS BAYOU SYSTEM (3.4 mi.$^2$) | |
| Brumps Sub-Basin | 2.3 |
| Pine Bluff Sub-Basin | 1.1 |
| ARKANSAS RIVER BASIN | 91.0 mi.$^2$ |

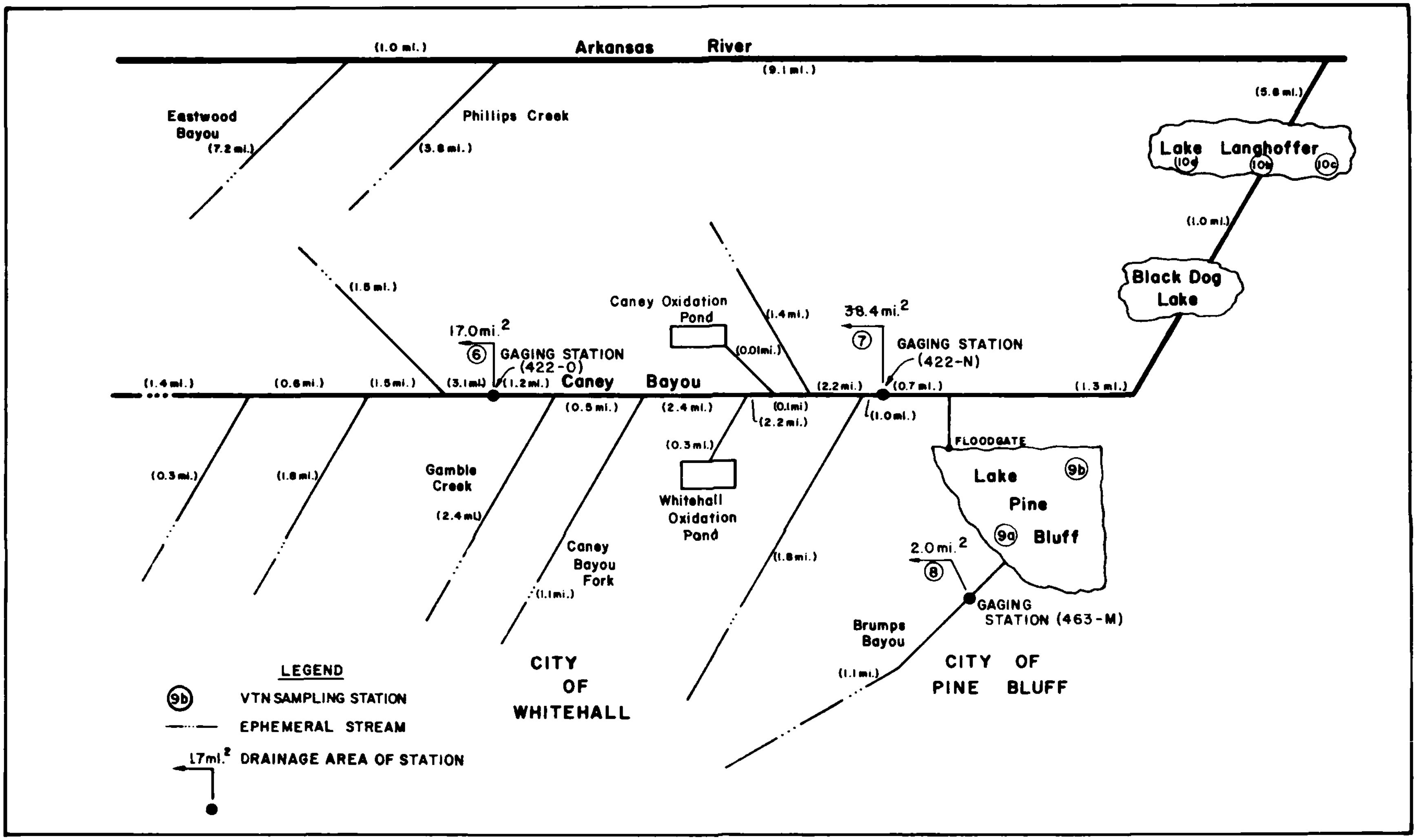



FIGURE II-11: SCHEMATIC FLOW OF THE ARKANSAS RIVER TRIBUTARIES WITHIN THE STUDY AREA

into Lake Langhofer, Caney Bayou's main channel is approximately 21 miles. Major tributaries that flow into Caney Bayou include Gamble Creek and Caney Bayou Fork, along with a number of unnamed tributaries.

In the upland terraces, Caney Bayou slopes about 15 feet per mile, but diminishes to approximately two feet per mile on the Alluvial Plain (U.S. Army Corps of Engineers, 1973b). Periodically, during high flow conditions, Caney Bayou's flow is hindered due to logs and litter accumulations that usually occur at the Baldwin Road and County Road bridges near Lake Pine Bluff. During the summer months, particularly in the upper reaches above Highway 79, flows are insufficient to prevent the encroachment of willows, river birch and other vegetation into the channel. During increased flow, this vegetation serves as a baffle area, accumulating debris and altering flows, velocities and channel configurations. During high flows on the Arkansas River, backwater intrusion into the Caney Bayou system is common. Two segments of Caney Bayou have been channelized; a short segment (0.1 miles) along the oxidation pond along the Pine Bluff Arsenal, and a segment (1.3 miles) beginning at the County Road Bridge near Lake Pine Bluff and terminating at Black Dog Lake. The drainage area of the Caney Bayou system is a little over 38 square miles and is subdivided into six sub-basins which are listed in Table II-6.

2. The Brumps Bayou System.

Brumps Bayou flows into the southwestern portion of Lake Pine Bluff. These waterways are connected to Caney Bayou via a sluice gate in the northwestern corner of Lake Pine Bluff. This gage and the pumps on the eastern levee of Lake Pine Bluff are only in operation during periods of heavy rainfall or deliberate drawdowns of the lake. Brumps Bayou falls an average of 14 feet per mile from its western source to its confluence with Lake Pine Bluff. The upper reaches of the bayou consist of a network of drainage ditches which are dry during non-storm periods and, in the lower reaches, the water is stagnant. Within the system, obstructions to flow are abundant and include trash and litter, surplus construction fill, old automobiles, vegetation, logs, pilings and a series of culverts. Flows are also modified by the water level of Lake Pine Bluff. Under normal conditions, the lake's water intrudes appreciably into the channel and the gradient is moderate. During periods of lake drawdown (summer, 1974), the gradient is markedly increased with coincident increases in flow.

The other component of the Brumps system is Lake Pine Bluff which is a 500-acre impoundment constructed by the Arkansas Game and Fish Commission and the City of Pine Bluff in 1962. The lake was formed after a levee system was constructed around a historic channel of the Arkansas River. With a mean depth of eight feet, the lake has a capacity of 4,000 acre-feet. Formerly a part of the Caney Bayou system, Lake Pine Bluff is treated as a distinct sub-basin receiving water from Brumps Bayou, rainfall and drainage from lands immediately adjacent to the lake. The total area of the sub-basin is small (1.1 square miles). The drainage area of the Brumps Bayou system is about 3.4 square miles.

3. The Arkansas River System.

The Arkansas system consists of numerous minor tributaries which drain the eastern edge of the Study Area directly to the Arkansas River. It also includes Lake Langhofer, or "Slackwater Harbor", which was formed by blocking the former river channel. This lake serves as the receiving body for the Caney Bayou system and other lesser tributaries. The total drainage area of the system is 49.2 square miles.

Lake Langhofer is an important sub-unit in the Arkansas system (completed in 1966), which extends for eight miles from the northwest levee to the breakwater structure in the northeast corner. It encompasses nearly 2,000 acres in surface area and at a mean depth of 15 feet, it has a capacity of 30,000 acre-feet. As a major harbor, in 1970 Lake Langhofer had a total tonnage of 307,400 primarily in chemicals, sand, gravel, iron and steel (U.S. Army Corps of Engineers, 1974a). See also Plate II-1.

The drainage area of Lake Langhofer is not delineated and land use consists principally of cleared pasture and agricultural lands, bottomland dominated by water-oak and river birch, industry along the southeastern shore (part of Pine Bluff and Southwestern Railway), small urban-residential areas along the southern shore, Island Harbor Marina on Boyd Point and other recreational facilities.

(b) The Ouachita River Basin.

The Ouachita-Black River and its tributaries drain an area of 24,237 square miles in Arkansas and Louisiana, of which 6,000 square miles lie within the alluvial valley of the Mississippi River (U.S. Army Corps of Engineers, 1973c).

Within the Study Area, the Ouachita River Basin is the largest hydrologic unit, covering 123.7 square miles of the southern portion of the Study Area. Table II-7 gives the systems, sub-basins and square mileage for the Ouachita River Basin. A schematic of the Ouachita River Basin is presented in Figure II-12. This schematic graphically illustrates the major surface water features of this drainage basin, showing major tributaries, channel lengths and gaging stations. It should be noted that most streams in the Study Area begin as ephemeral streams.

1. The Bayou Bartholomew System.

From its headwaters, Bayou Bartholomew flows southeastward with slopes of 3.5 feet per mile on the terrace to 1.0 and 0.5 feet per mile on the alluvial plain. It departs the Study Area in the southeastern corner. The reach of the main channel is 29.4 miles and the total drainage area of the system is 103.5 square miles.

As indicated on the Ouachita River Basin schematic (Figure II-12), there are a number of major tributaries entering the bayou: 1)Interceptor Canal, which drains the interior of the city; 2)Nevins Creek, which enters from the southwest and drains an area of upland forest and pasture; 3)Bayou Imbeau, an oxbow slough which enters from the east and serves as a natural catch basin for much of the agricultural land; 4)Outlet Canal, a complex drainage system for the city, and 5)Boggy and Sandy bayous, which collect waters from an area of upland and bottomland forests to the west.

Outlet Canal was constructed in 1934 to divert storm water from the Harding Drain sub-basin, which, with the growth of the City, was unable to accommodate storm waters during high stages on the Arkansas River; water was thus ponded in the downtown area. During low river stages, a floodgate could release the ponded waters from the northeast corner of Pine Bluff to the Arkansas River.

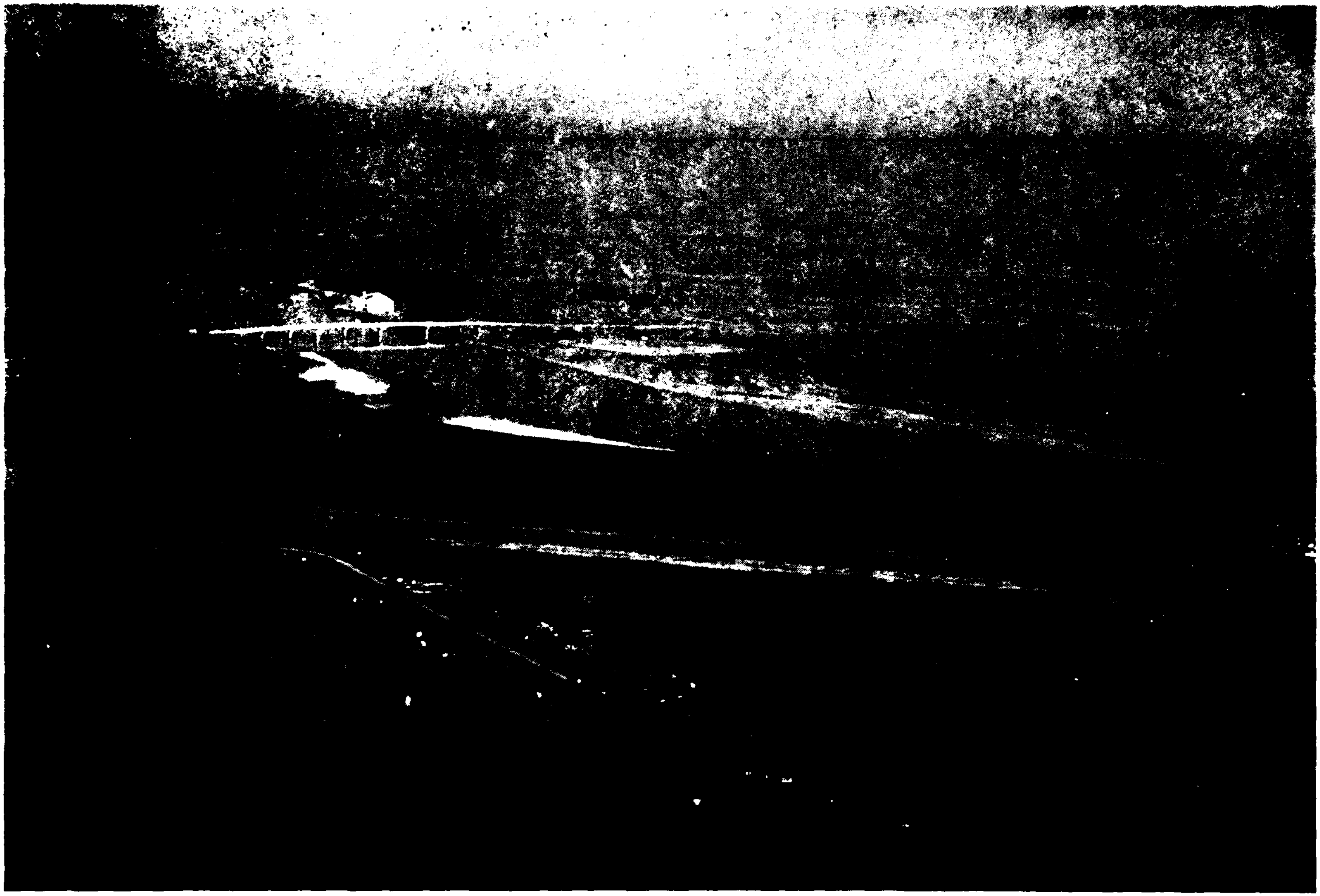


Plate II-1 Lake Langhofer at northwest levee separating it from the Arkansas River

Table II-7

The Ouachita River Basin, Systems and Sub-Basins
Within the Study Area

| | |
|---|---|
| BAYOU BARTHOLOMEW SYSTEM (103.5 $mi.^2$) | - |
| Princeton Pike Sub-Basin | 11.0 |
| St. Luke Sub-Basin | 3.2 |
| Flying Duck Sub-Basin | 4.0 |
| Upper Bartholomew I Sub-Basin | 4.3 |
| Upper Bartholomew II Sub-Basin | 1.6 |
| Gravel Sub-Basin | 5.7 |
| Sulphur Springs Sub-Basin | 2.2 |
| Nevins Sub-Basin | 3.8 |
| Lower Nevins Sub-Basin | 1.0 |
| Watson Chapel Sub-Basin | 1.8 |
| Southwestern Sub-Basin | 2.7 |
| Liberty Sub-Basin | 4.5 |
| Boggy Sub-Basin | 4.9 |
| Lower Boggy Sub-Basin | 7.9 |
| Sandy Sub-Basin | 11.8 |
| Lower Sandy Sub-Basin | 1.5 |
| Bartholomew at Pinebergen Sub-Basin | 3.4 |
| Lower Bartholomew Sub-Basin | 4.7 |
| Imbeau Sub-Basin | 3.8 |
| Middle Bartholomew Sub-Basin | 4.8 |
| Eden Park Sub-Basin | 2.2 |
| Interceptor Sub-Basin | 2.5 |
| Harding Drain Sub-Basin | 1.2 |
| Pitts Drain Sub-Basin | 1.5 |
| Lamont Sub-Basin | 1.0 |
| Outlet Sub-Basin | 4.8 |
| Town Branch Sub-Basin | 0.9 |
| Belmont Sub-Basin | 0.8 |
| DEEP BAYOU SYSTEM (20.2 $mi.^2$) | 20.2 |
| OUACHITA RIVER BASIN | 123.7 $mi.^2$ |

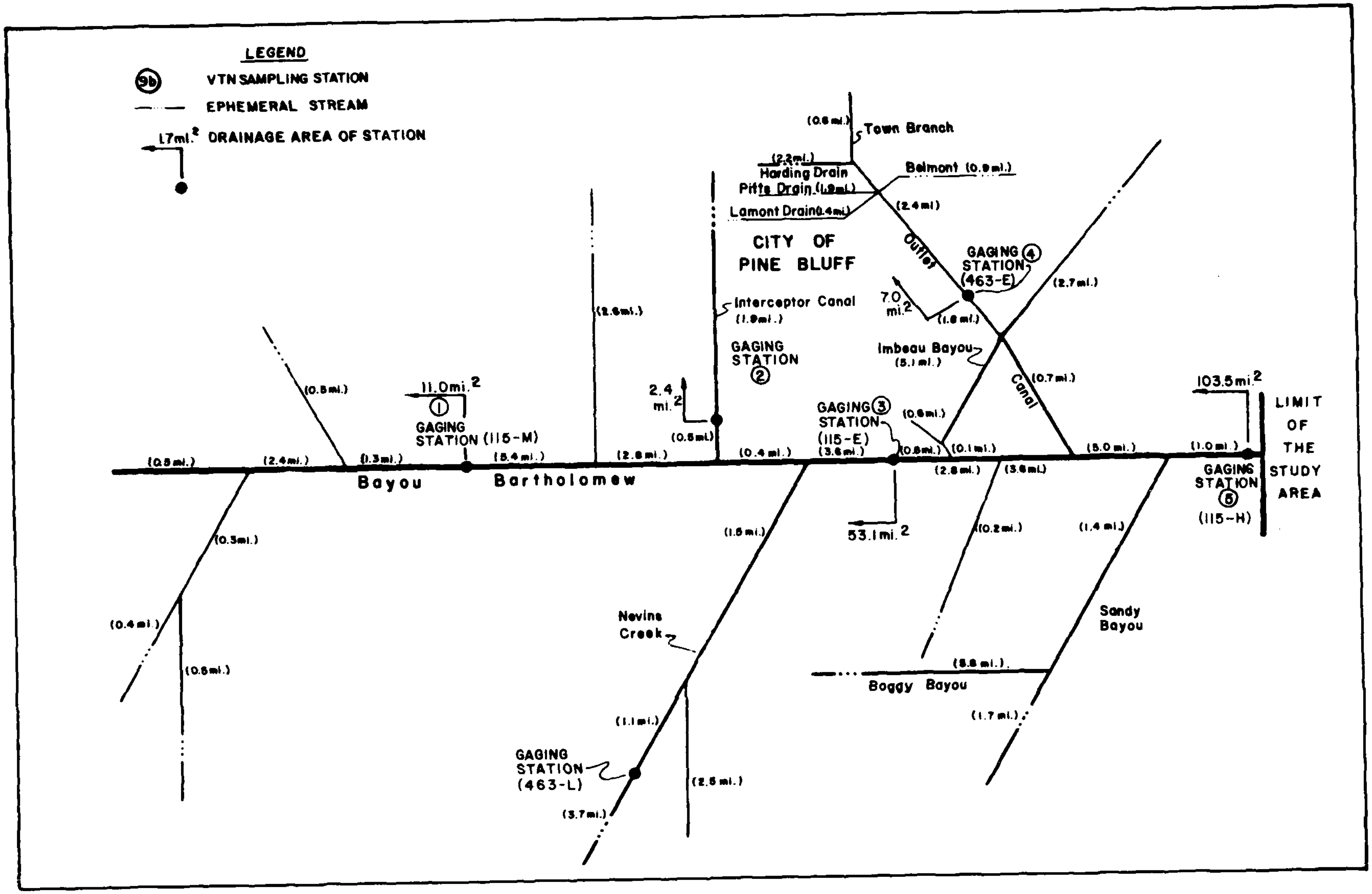



FIGURE II-12: SCHEMATIC FLOW OF THE OUACHITA RIVER TRIBUTARIES WITHIN THE STUDY AREA

In its present configuration, Outlet Canal is the main stem for a number of important urban drainage sub-basins: Harding Drain, Town Branch, Pitts Drain and several unnamed channels (Figure II-10). Storm waters from Town Branch are capable of being discharged to the Arkansas River coincident with low stages on that river. However, as drainage is normally southward, Town Branch and its sub-basin are considered to be members of the Bayou Bartholomew system and the Ouachita Basin. The total reach of Outlet Canal is 4.9 miles with slopes of approximately 0.5 feet per mile. Within Outlet Canal, drainage is inhibited by litter and log jams at bridges, vegetation including extensive mats of alligator weed and low slopes (Plate II- 2).

Interceptor Canal was constructed in 1954 to provide flood water relief for the Harding Drain-Outlet Canal sub-basin. The flow of storm waters originating from the western end of Harding Drain and paralleling the St. Louis Southwestern Railroad is intercepted and discharged directly into Bayou Bartholomew. The canal also collects storm water flow from the east as storm sewer installations have extended its eastern drainage boundary. Recently, Interceptor Canal has been cleared and snagged for drainage improvement. The total reach of the canal is 2.4 miles.

At low flow periods, much of the upper ephemeral reaches of Bayou Bartholomew and its tributaries is dry. Some forecasts indicate that with the absence of available recharge due to ground water pumpage, the extent of dry beds or markedly reduced flows will increase (Broom and Reed, 1974). Restrictions to flow in the main channel of Bayou Bartholomew are primarily due to vegetation encroachment into the channel. In the upper reaches, the vegetation is typically river birch and willow and in the lower reaches cypress and willows.

The Bayou Bartholomew System is divided into 28 sub-basins, which are listed in Table II-7. Although both agricultural and urban land use dominate specific sub-basins, the drainage area of the Bayou Bartholomew System as a whole is primarily forest communities (both upland and bottomland) and cleared lands (pastures and clear-cuts). In summary, the basin is dominated in drainage by its undeveloped western lands.

2. The Deep Bayou System.

The Deep Bayou System is located along the southeastern edge of the Study Area. Within the Study Area, this system is only one ephemeral stream. It lies totally within the alluvial plain and flows, during wet periods, to the south following a slope of approximately 0.5 feet per mile. The total drainage area of the Deep Bayou System is 20.2 square miles.

(2) Commercial Navigation.

The Arkansas River is the only commmercially navigable waterway within the Study Area that can accommodate barge traffic. The channel dimensions of the Arkansas River are nine feet by 300 feet and are currently being maintained by the Little Rock District of the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 1974a). Almost all of the remaining waterways are navigable for small pleasure craft and flat boats.

Plate II-2 Outlet Canal above 38th Street

(3) Streamflow.

(a) Monitoring.

Streamflow measurement stations in the Study Area have provided a very brief hydrologic record. Presently, most flow recording stations are equipped with automatic water-stage recorders. Earliest continuous discharge records began in 1974. These stations are maintained by the U.S. Army Corps of Engineers.

(b) Discharge.

Since only one year of discharge data has been gathered for the Pine Bluff area, the presentation of this data (Table II-8) will only have hydrologic ranges for the stations in the Study Area. Unit hydrographs for the streams within the Study Area are appended (Figures A-1 through A-7).

(c) Flooding.

Flooding and flood protection and associated problems have been discussed in Section II.D.1.e.(5). Additionally, destructive flooding in the past is treated by river basin below.

1. The Arkansas River Basin.

The 1927 flood is considered to be the most disastrous flood to occur in the vicinity of the Study Area. The unusually heavy and constant rains began to swell the rivers of Arkansas and the entire Mississippi Valley, in early January. By April, 1927, the unrelenting rain had soaked 31 states and two Canadian provinces with a downpour totaling 250 cubic miles of water - enough to cover the entire area with over a foot of water. Even after absorption and evaporation, more than 60 cubic miles of water had to find its way to the Gulf of Mexico. In Pine Bluff, some of the most severe flooding has resulted from summer thunderstorms, with the storms of July, 1951 and August, 1970 being the most memorable (U.S. Army Corps of Engineers, 1973b).

2. The Ouachita River Basin.

The maximum flood recorded for Bayou Bartholomew occurred in May, 1958. It had an estimated average frequency of occurrence of about once in 50 years. Rainfall over the upper basin averaged 20 inches for the period April 25 through May 20, with five inches of rainfall recorded at Pine Bluff during a 15-hour period. The rains which contributed to the flooding of Bayou Bartholomew in May, 1958, also produced flooding in Pine Bluff along Harding Drain (U.S. Army Corps of Engineers, 1973a).

b. Summary and Relationships of Surface Water Resources to the Study Area.

Surface water resources within the Study Area are abundant. The Arkansas River, Lake Langhofer, Lake Pine Bluff and Bayou Bartholomew and tributaries are the most important lakes and waterways located in and adjoining the Study Area.

The hydrologic resources of the Study Area molded by its topography, its soils and its climates, play a major role in its environmental, social and

Table II-8
Hydrologic Ranges on Selected Stations in the Pine Bluff Study Area

| STATION<br>(STATION PROFILE NUMBER) | GAGE ZERO FT. MSL | DAILY MEAN VELOCITY (F.P.S.) | DAILY MAXIMUM VELOCITY (F.P.S.) | GAGE HEIGHT (FEET) | DISCHARGE (C.F.S.) | PERIOD OF RECORD (OPERATED FOR ALL STATIONS) |
|---|---|---|---|---|---|---|
| Harding Drain at Tennessee Street (270+20) | 186.7[illegible] | 0.[illegible] - 5/31/74<br>0.11 - 6/ 6/74 | [illegible] - 5/31/74<br>0.2[illegible] - 6/ 6/74 | 13.49 - 6/ 8/74<br>10.95 - 4/11/74 | 129 -11/27/73<br>0.18- 6/ [illegible] | 11/[illegible] - 9/[illegible] |
| Outlet Canal at 38th Extension (128+90) | 181.74 | 1.61 - 11/27/73<br>0.1[illegible] - 6/ 8/74 | 3.30 - 6/ 7/74<br>0.30 - 3/26/74 | [illegible] - 6/ 7/74<br>10.60 - 4/11/74 | [illegible]<br>1.2 - [illegible] | 11/2[illegible] - 9/[illegible] |
| Tributary B to Outlet Canal (Pitts Drain) Louisiana St. (53+40) | 192.2[illegible] | 4.68 - 2/[illegible]/74<br>0.10 - [illegible]/15/74 | 4.87 - 2/21/74<br>0.16 - 2/15/74 | 13.[illegible] - [illegible]<br>10.6[illegible] - 2/15/74 | 62.3 - [illegible]<br>0.23- [illegible] | [illegible] - 9/[illegible] |
| Interceptor Canal at West [illegible] Avenue (27+[illegible]) | 204.27 | 4.[illegible] - 6/ 7/74<br>0.17 - 2/15/74 | 7.40 - 6/ 7/74<br>0.21 - 2/15/74 | [illegible] - 6/ 7/74<br>11.27 - 2/15/74 | 71[illegible] - 6/ [illegible]<br>0.6 - 2/15/7[illegible] | [illegible] - 9/[illegible] |
| Eden Park Drain at Arkansas Highway 15 (76+10) | 191.9[illegible] | 2.01 - [illegible]/74<br>0.34 - 5/15/74 | 2.44 - [illegible]/21/74<br>0.4 - 4/23/74 | 15.[illegible] - [illegible]/21/74<br>10.11 - 4/11/74 | 365 - [illegible]<br>[illegible] - 2/15/7[illegible] | [illegible] - 9/[illegible]<br>[illegible] - 9/[illegible] |
| Boggy Bayou at County Road (100+00) | 197.00 | 1.31 - 2/21/74<br>0.32 - 2/15/74 | 1.[illegible] - 2/[illegible]/74<br>0.41 - [illegible]/15/74 | 15.74 - 6/ 8/74<br>10.72 - 5/23/74 | [illegible] - [illegible]<br>0.07- 5/[illegible] | [illegible] - 9/[illegible] |
| Bayou Bartholomew at Arkansas Highway 15 (500+00) | 185.49 | 1.4[illegible] - 6/ 8/74<br>0.04 - 4/11/74 | 3.31 - 6/ 8/74<br>0.17 - 4/11/74 | 17.88 - 6/ 8/74<br>8.80 - 4/11/74 | [illegible],920 - 6/ 8/7[illegible]<br>6.7 - [illegible] | [illegible] - [illegible] |
| Brumps Bayou at U.S. Highway 65 (53+[illegible]) | [illegible]9.9[illegible] | [illegible]7 - 1/10/7[illegible]<br>0.1[illegible] - 4/1[illegible]/74 | 2.97 - 1/10/74<br>0.1[illegible] - 4/1[illegible]/74 | [illegible].99 - 1/10/74<br>13.9[illegible] - 1/ 9/74 | 15[illegible] - 1/10/7[illegible]<br>1[illegible] - [illegible] | [illegible] - 9/30/[illegible]<br>[illegible] - 9/30/[illegible] |
| [illegible] Creek at Arkansas Highway 54 (20[illegible]+[illegible]) | [illegible]14.[illegible] | 2.5[illegible] - 4/12/74<br>0.4[illegible] - 4/11/74 | [illegible] - 4/12/74<br>0.98 - 4/11/74 | 15.[illegible]9 - [illegible]/21/74<br>10.04 - 4/11/74 | [illegible] - [illegible]<br>1.4 - [illegible] | [illegible] - [illegible] |
| Bayou Bartholomew at Princeton Pike Road (1,1[illegible]+50) | [illegible]7.23 | 4.02 - 6/ 7/74<br>0.17 - 3/26/74 | 5.84 - 6/ 7/74<br>0.27 - 3/26/74 | [illegible].80 - 6/ 7/74<br>1[illegible] - 4/11/74 | [illegible],0[illegible]0 - 6/ 7/7[illegible]<br>[illegible] - 4/11/7[illegible] | [illegible] - 9/30/7[illegible] |
| Bayou Bartholomew at Pinebergen, Arkansas | 173.3[illegible] | 1.83 - 6/ 8/74<br>0.08 - 4/11/74 | [illegible].5[illegible] - 6/8/74<br>0.1[illegible] - 4/11/74 | [illegible].7[illegible] - 6/ 8/74<br>1[illegible].89 - 4/11/7[illegible] | [illegible],[illegible]1[illegible] - 6/ 8/7[illegible]<br>[illegible] - [illegible] | [illegible] - [illegible] |
| Bayou Bartholomew at U.S. Highway [illegible]9 ([illegible]) | [illegible].[illegible]9 | 1.[illegible] - [illegible]<br>0.10 - [illegible] | [illegible] - [illegible]/74<br>0.3[illegible] - [illegible]/74 | [illegible].9[illegible] - 6/ 8/7[illegible]<br>1[illegible] - [illegible]/15/73 | [illegible] - [illegible]<br>[illegible] - [illegible] | [illegible] - [illegible]<br>[illegible] - [illegible] |
| Caney Bayou at U.S. Highway [illegible] ([illegible]9+4[illegible]) | [illegible].76 | [illegible].95 - 6/ [illegible]/74<br>0.11 - 3/26/74 | 4.7[illegible] - 6/ 7/74<br>[illegible] - 3/2[illegible]/74 | [illegible] - [illegible]<br>[illegible].9 - 8/[illegible]/74 | [illegible] - [illegible]<br>[illegible] - [illegible] | [illegible] - [illegible] |
| Caney Bayou at Wooden Bridge on [illegible] Road above Lake Pine Bluff (151+7[illegible]) | 184.67 | 2.54 - 6/ 8/74<br>0.06 - 3/2[illegible]/74 | [illegible] - 6/ 8/74<br>0.1[illegible] - 3/26/74 | 19.[illegible] - 6/ [illegible]/74<br>[illegible] - [illegible]/13/74 | [illegible],7[illegible] - [illegible]<br>[illegible].9 - [illegible]/15/7[illegible] | [illegible] - [illegible] |

Source: U.S. Army Corps of Engineers, 1974.

economic aspects. The proximity of lakes and streams allow the area to support a growing population and remain attractive for both agriculture and industry. Surface water sources supply relatively small amounts of water for industrial uses, irrigation and fish farms and supply the major portion of the water used for watering livestock. In addition, streams, lakes and ponds of the area offer considerable recreational opportunity (i.e., boating, fishing) and provide much in the way of esthetic enhancement. The Arkansas River and associated slack water harbor (Lake Langhofer) provide an economic route for the transportation of goods and a viable and growing port facility.

The variety of surface waters from the narrow, braided channels of upper Bartholomew and Caney bayous and the small lakes and ponds of the uplands, to the broad meandering systems of the alluvial plain (including the lower reaches of Bayou Bartholomew, Caney Bayou, the Arkansas River, extensive back-water areas, oxbow lakes and sloughs) afford the area a particularly diverse environ for aquatic-oriented life. The quality of these surface waters, in turn, determines the abundance and diversity of aquatic life which also influences such aquatic-oriented animals as some birds, amphibians and reptiles. Other birds and wildlife species (i.e., deer, raccoon) also depend on the surface waters as a water or food source.

The hydrologic resources of the area are also a major part of one of the area's key problems: flooding. Although flood protection has increased over the past few years, particularly along the Arkansas River, flooding is still a concern along the lower portions of Bayou Bartholomew. The combination of low relief, channels obstructed by dense tree growth, drift, debris and high runoff from the impervious surfaces of the Pine Bluff Metropolitan Area, combine to produce damaging floods in the vicinity of Bayou Bartholomew. Accentuated urban development in and adjacent to the floodplain of Bayou Bartholomew, and to a lesser extent Caney Bayou, has resulted in a condition where major floods could be devastating to both property and life.

The hydrologic regimes of both Caney Bayou and Bayou Bartholomew (and their tributaries) are also tied to their water quality. Flows determine in large part the ability of the streams to assimilate pollution. In the upper reaches of Bayou Bartholomew and Caney Bayou, where flows above 100 cubic feet per second are rare, they must be considered more fragile or more susceptible to pollution than the lower reaches. Flows, too, are responsible for the sediment load of a particular reach and for the causal agent in streambank erosion.

3. Ground Water Resources.

The varied and growing demands for water in Jefferson County and the Study Area are satisfied primarily by ground water. Of the approximately 122 million gallons of water per day (MGD) used in Jefferson County, 111 MGD or 91 per cent is from ground water aquifers of the Tertiary and Quaternary strata. Jefferson County ranks third behind Lonoke and Arkansas counties in total ground water withdrawal (Halberg, 1972).

The principal aquifers of Jefferson County are the Sparta Sand Formation of Tertiary origin, and the undifferentiated alluvial deposits of Quaternary origin. Several aquifer systems exist in the Paleozoic strata, Cretaceous and lower Tertiary systems, however; they have not, as of yet, been developed due to this low capacity, poor water quality and/or extreme depths.

The following discussion treats each of the currently utilized aquifer systems as they occur in the stratigraphic column (Figure II-4). With each aquifer, the physical characterisitics are described first, followed by a discussion of its hydraulics. Water utilization is covered in Section II.D.4. Ground water quality is presented in Section IV.

a. The Eocene Aquifer System.

The Sparta Sand Formation (Claiborne Group) is the principal source of water for municipal and industrial supply wells in southeastern Arkansas. The Sparta Sand overlies the Cane River Formation and consists of fine to medium grained massive sands with beds and lenses of clay and sandy clay. The Sparta Sand is of continental origin with evidence of reworked materials of older strata by streams (Klein et al., 1950). In thickness, the Sparta Sand Formation varies from 450 to 800 feet. In the northwest corner of Jefferson County, the Sparta Sand Formation is at sea level; in the southeastern portions it dips to 900 feet below sea level. Wells tapping the Sparta Sand are 800 to 1,000 feet in depth (Klein et al., 1950 ; and International Paper, pers. comm.). Table II-9 presents the major wells in the Pine Bluff Study Area that penetrate to the Sparta Sand. Well locations are presented in Figure II-13. The Sparta extends for many miles to the northeast, east and south. To the west, the Sparta Sand crops out into a north-south band several miles wide west of Jefferson County. This outcropping is a principal recharge area (Figure II-14) and is crossed by several perennial streams. To the north, the Sparta Sand Formation rises to contact the overlying Quaternary deposits. The base of the Quaternary deposits is quite permeable and contains large quantities of water available for recharge (Klein et al., 1950).

Flow within the Sparta Sand aquifer is generally southeastward following the contours of the current potentiometric surface (Figure II-15). In Jefferson County, as in the vicinity of the cities of Magnolia and El Dorado, flow is toward the center of large cones of depression which have developed with recent increased pumpage.

Transmissivity (T) and the coefficient of storage are often used to describe an aquifer's ability to transmit and store water. Transmissivity is expressed in gallons per day per foot and the storage coefficient is dimensionless and expressed as a decimal fraction. Both values are used for quantifying the aquifer's response to stress (Hosman et al., 1968).

Tests for transmissivity and storage were reported by Hosman et al. (1968). The average transmissivity, based on five tests of the Sparta Sand in Jefferson County, was 100,000 gallons per day per foot. The coefficient of storage for the source was 0.0002. Compared to other areas tested in Arkansas, the coefficient of storage was generally the same, however, the transmissivity was exceptionally high (Hosman et al., 1968).

Based on the most recent estimates available, the Sparta Sand aquifer system is producing a combined yield of about 50 million gallons per day (Table II-9). Of this total, approximately 7.8 MGD is withdrawn by General Water Works of Pine Bluff (pers. comm.) and 42 MGD by industry and commerce (U.S. Army Corps of Engineers, pers. comm.). With recent heavy industrial withdrawals, a cone of depression has formed in Jefferson County and centered in Pine Bluff (Figure II-15). It is indicative not only of a large demand, but reflective of Pine Bluff's growing economic shift from agriculture to industry.

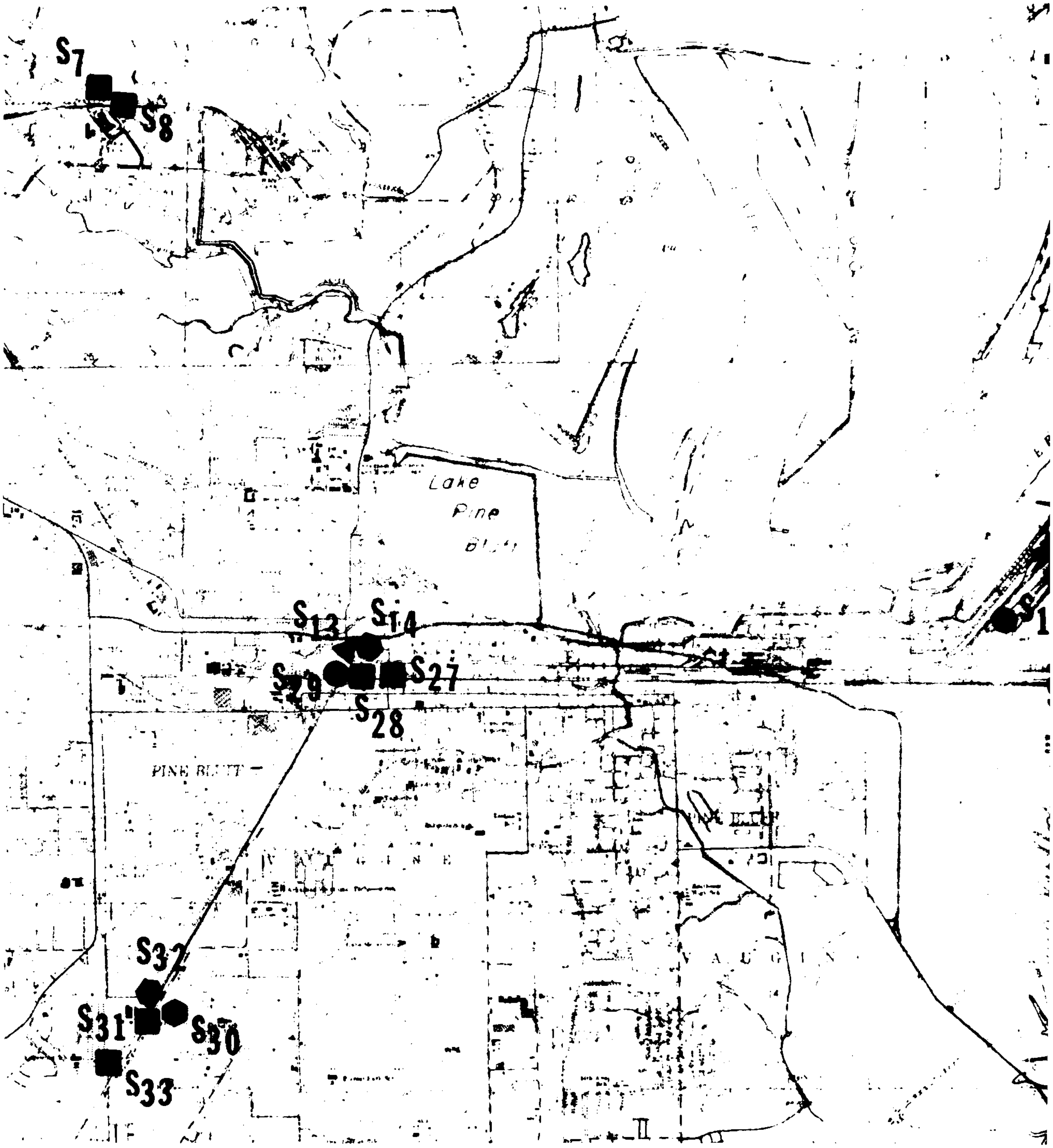
Table II-9

Major Sparta Sand Water Wells in the Pine Bluff Study Area
(Refer to Figure II-13)

| MAP CODE | LOCATION (SECTION-TOWNSHIP-RANGE) | DEPTH BELOW LAND SURFACE (FEET) | REPORTED DAILY WITHDRAWAL (GALLONS PER DAY) |
|---|---|---|---|
| S1 | 30-T5S-R8W | 924 | 1,866,730 |
| S2 | 30-T5S-R8W | 934 | 1,730,140 |
| S3 | 30-T5S-R8W | 934 | 1,138,250 |
| S4 | 30-T5S-R9W | 827 | 1,821,200 |
| S5 | 30-T5S-R8W | 916 | 1,821,200 |
| S6 | 32-T5S-R8W | 1,000 | 1,957,790 |
| S7 | 19-T5S-R9W | 1,245 | 4,320,000* |
| S8 | 19-T5S-R9W | 939 | 4,320,000* |
| S9 | 25-T5S-R9W | 852 | 1,320,370 |
| S10 | 25-T5S-R9W | 844 | 1,593,550 |
| S11 | 25-T5S-R9W | 832 | 1,866,730 |
| S12 | 26-T5S-R9W | 800 | 1,866,730 |
| S13 | 31-T5S-R9W | 840 | ** |
| S14 | 31-T5S-R9W | 854 | ** |
| S15 | 35-T5S-R9W | 854 | 2,003,320 |
| S16 | 35-T5S-R9W | 811 | 1 138,250 |
| S17 | 35-T5S-R9W | 846 | 1,593,550 |
| S18 | 35-T5S-R9W | 822 | 1,183,780 |
| S19 | 35-T5S-R9W | 817 | 1,593,550 |
| S20 | 36-T5S-R9W | 813 | 2,003,320 |
| S21 | 36-T5S-R9W | 883 | 1,593,550 |
| S22 | 36-T5S-R9W | 856 | 1,866,730 |
| S23 | 8-T6S-R8W | 890 | 1,957,790 |
| S24 | 8-T6S-R8W | 951 | 1,866,730 |
| S25 | 9-T6S-R8W | 1,010 | 1,821,200 |
| S26 | 10-T6S-R8W | 957 | 2,003,320 |
| S27 | 4-T6S-R9W | 876 | ** |
| S28 | 4-T6S-R9W | 876 | ** |
| S29 | 4-T6S-R9W | 848 | ** |
| S30 | 17-T6S-R9W | 875 | ** |
| S31 | 17-T6S-R9W | 850 | ** |
| S32 | 17-T6S-R9W | 877 | ** |
| S33 | 17-T6S-R9W | 847.5 | ** |
| TOTAL | | | 49,727,780 |

Note: * Only one well is operated during alternate 6-month periods.
** These wells total 7.8 MGD.

Source: U.S. Army Corps of Engineers, pers. comm.; General Waterworks pers. comm.



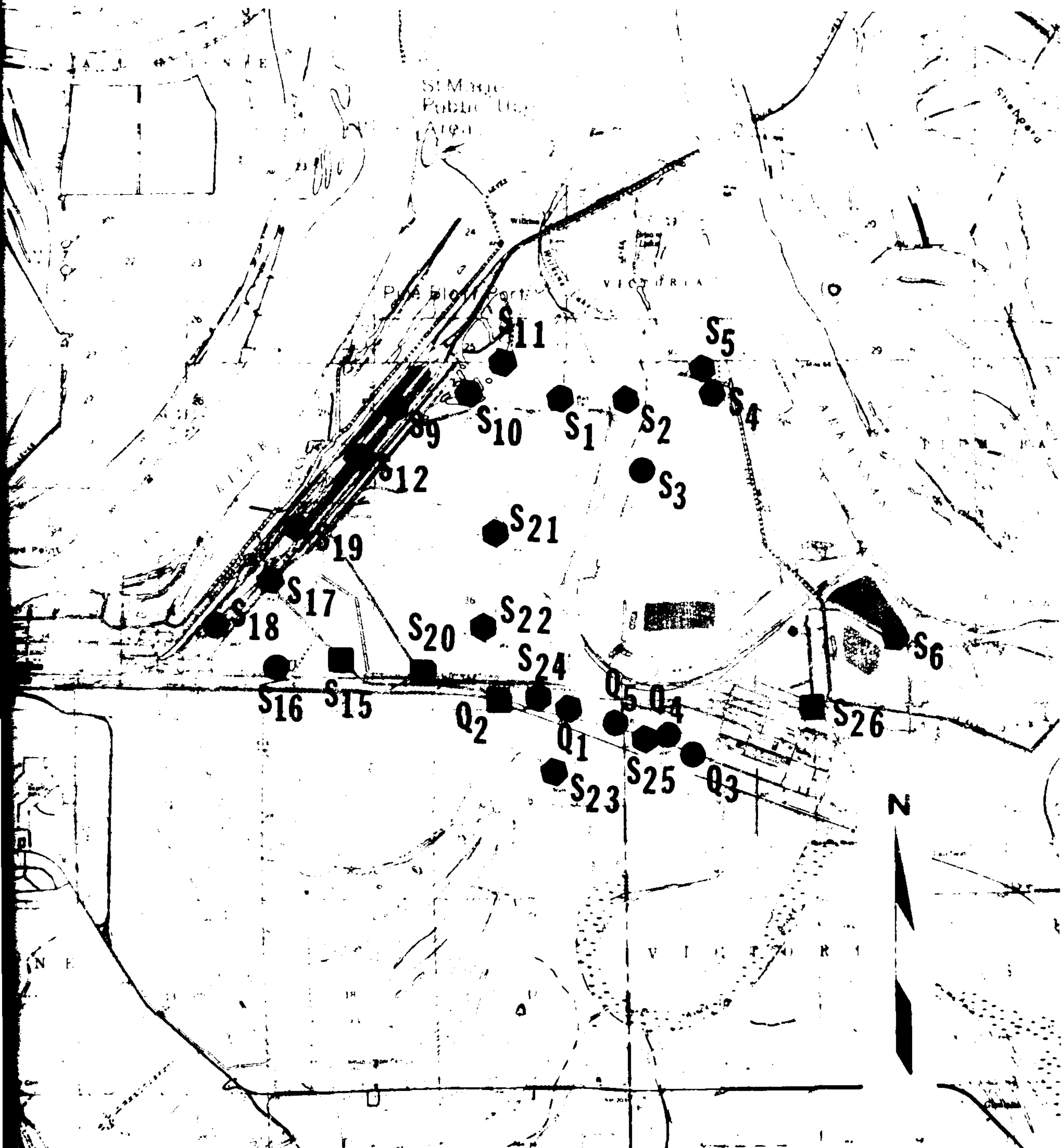

LEGEND

| | |
|---|---|
| S SPARTA WELL | ● 1,000,000 TO 1,500,000 gpd |
| Q QUATERNARY WELL | ⬢ 1,500,001 TO 2,000,000 gpd |
| ▲ LESS THAN 1,000,000 gpd | ■ GREATER THAN 2,000,000 gpd |

Note: Refer to Table II-9 for Map Codes.

MAJOR GROUND
OF THE PINE BL

SOURCE: U.S. Army Corps of Eng., pers. comm., General Water Works, pers. comm.




SCALE: 1" = 4000'

GROUND WATER WELLS
PINE BLUFF STUDY AREA

FIG. II - 13

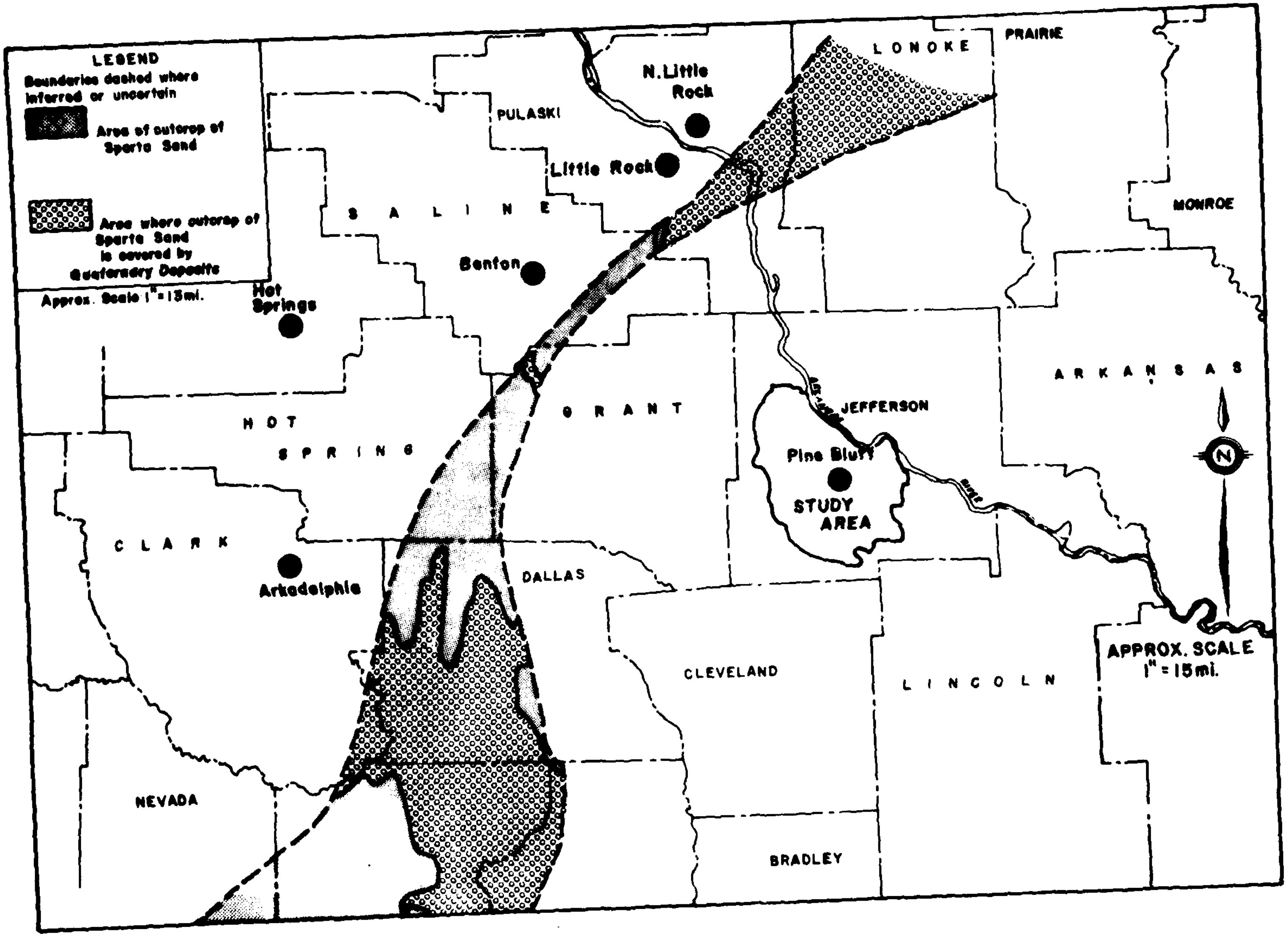



FIGURE II-14: AREA OF OUTCROP & RECHARGE OF SPARTA SAND

Source: Hosman et al., 1968.

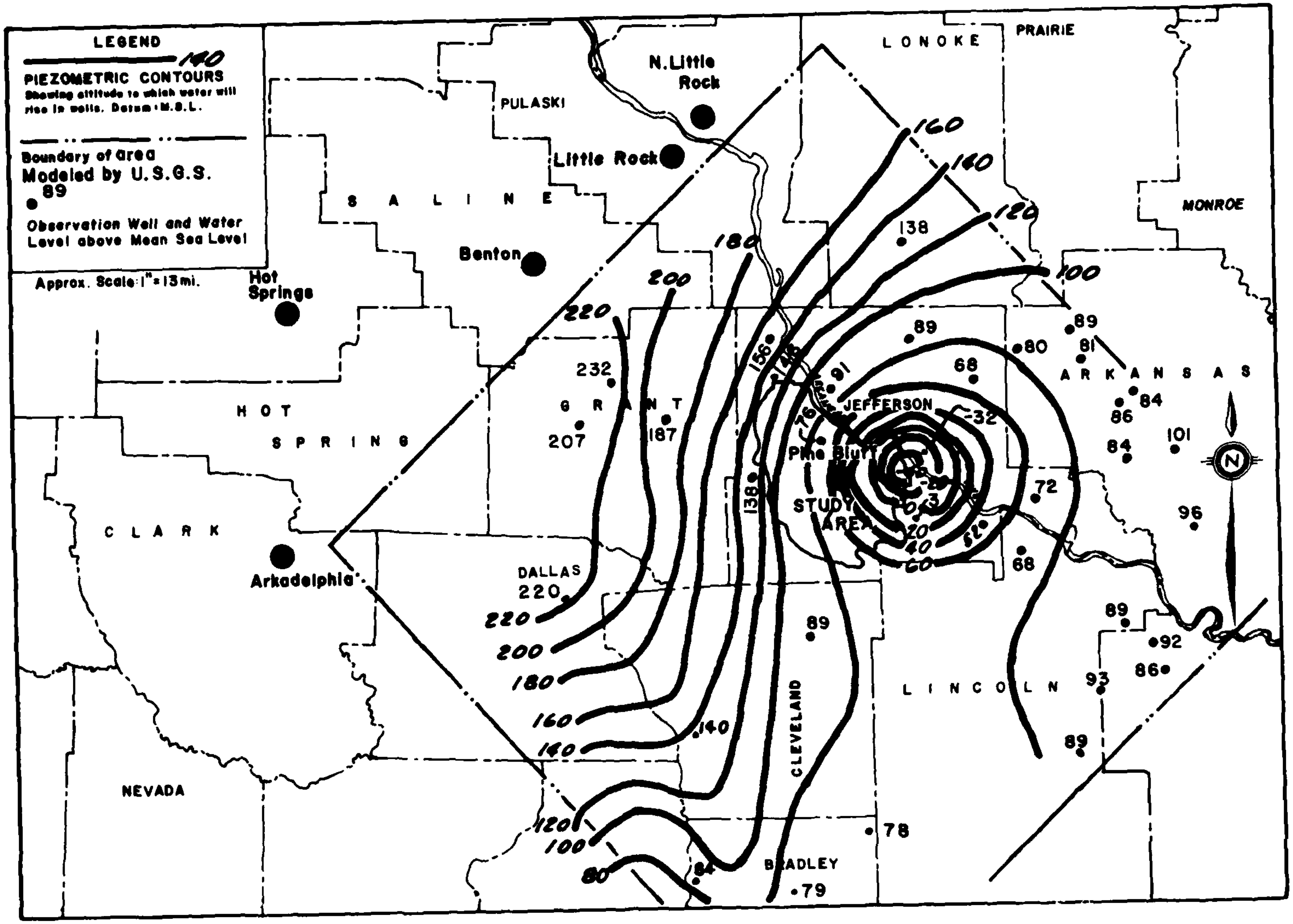



FIGURE II-15: POTENTIOMETRIC SURFACE OF THE SPARTA SAND AQUIFER
(BASED ON 1973 DATA)

Source: U.S. Army Corps of Engineers, pers. comm.

Historically, the water levels in the early wells of Pine Bluff ranged from 20-47 feet below ground level. By 1949, water levels had dropped to between 50 and 80 feet (Klein et al., 1950). In 1958, when pumpage for industrial use was greatly increased, the cone of depression began to assume its current configuration (Bedinger et al., 1960). Between 1958 and 1965, observation wells near the center of the cone had declined up to 160 feet and the cone extended laterally for several miles. Withdrawal rates and changes in the water levels between 1972 and 1973 (Table II-10) indicate that the cone of depression has not completely stabilized. Observation wells of International Paper suggest that the center of the cone now lies 42 to 49 feet below sea level; a drop of about 40 feet since 1965 (U.S. Geological Survey, 1973).

Within the Eocene Aquifer System there exists a second, less significant aquifer in the upper sands of the Cockfield Formation (Claiborne Group) and the lower undifferentiated sands of the Jackson Group. Throughout Jefferson County and most of south-central Arkansas, these sands form a single hydrologic unit which outcrops west of Jefferson County (Figure II-16). The units dip southward toward the axis of the Mississippi Embayment, increasing in thickness to approximately 600 feet in the southeast. Recharge to the aquifer (Figure II-16) is in the form of precipitation on the outcrop and seepage from the overlying Quaternary alluvium. Excess or rejected recharge contributes to the baseflow of streams. Movement within the aquifer unit is southward (Hosman et al., 1968).

Wells tapping the Cockfield-Jackson aquifers pump about 0.36 MGD (1970) and are located principally in the western part of Jefferson County (Halberg, 1972). The individual beds are usually artesian but do not yield large amounts of water. Principal usage includes domestic and small public supplies. In the vicinity of Redfield, water is found 160 feet above sea level and near Pine Bluff, quality water can be obtained from depths ranging from 150 to more than 300 feet below the surface (Klein et al., 1950). Increased pumpage from the Cockfield-Jackson aquifers may eventually deplete water storage in the overlying alluvium (Hosman et al., 1968).

b. The Quaternary Aquifer System.

The undifferentiated deposits of the Quaternary System serve as a second major source of ground water for the Pine Bluff Metropolitan Study Area. Within the Study Area, west of Bayou Bartholomew, the Quaternary System consists of Pleistocene terrace deposits; to the east, the Study Area is blanketed with Holocene alluvium. As both terrace and alluvial deposits are similar in composition and hydrologic properties, they will be considered as a single unit termed alluvium (Broom and Reed, 1973; Klein et al., 1950).

The Quaternary deposits vary in thickness from a few feet where the alluvium rests against the outcropping Jackson unit to 250 feet in the vicinity of Pine Bluff. The alluvium can be divided in three zones. The basal zone consists of lenses of coarse sand and gravel with some sand and clay. The gravel consists largely of chert, quartz and pebbles of sandstone and igneous rock. Cobbles and boulders also commonly occur at the base of the alluvium. The depth of the basal zone varies considerably and is thickest where it fills cuts in the surface of the underlying Eocene strata. The intermediate zone consists of medium and fine sand. The upper zone of silts and clay (25 to 50 feet thick) forms a semi-confining cap over the alluvial aquifer (Albin et al., 1967; Fisk, 1944; Broom and Reed, 1973; Klein et al., 1950). The gravel and coarse sands of the alluvium's basal zone comprise the principle aquifer capable of storing and transmitting large quantities of water.

Table II-10

Comparison of Water Levels in Sparta Sand Observation Wells
Spring 1972 - Spring 1973

| USGS WELL NUMBER | ALTITUDE OF LAND SURFACE IN FEET (MSL) | ALTITUDE OF WATER LEVEL | | CHANGE | WELL IDENTIFICATION |
|---|---|---|---|---|---|
| | | 1972 | 1973 | | |
| 3S8W-19bdbl | 215 | 93 | 89 | -4 | Tucker Prison |
| 3S11W-22abcl | 310 | 154 | 158 | +4 | Redfield P.S. |
| 4S7W-17bccl | 200 | 72 | 68 | -4 | Wabbaseka P.S. |
| 4S10W-29adbl | 268 | 99 | 97 | -2 | P.B. Arsenal |
| 4S11W-14badl | 400 | 126 | 126 | 0 | Jefferson P.S. |
| 5S8W-30adbl | 221 | -38 | -38 | 0 | Lock & Dam No. 4 |
| 5S8W-30cbal | 207.46 | -47 | -49 | -2 | Int. Paper Co. No.F |
| 5S9W-19baal | 227.16 | 5 | 25 | +20* | Dierks No. 2 |
| 5S9W-19badl | 219.78 | 25 | -5 | -30* | Dierks No. 1 |
| 5S9W-24dbdl | 208.17 | -28 | -32 | -4 | Int. Paper No. 10 |
| 5S9W-35aabl | 204.67 | -41 | -44 | -3 | Int. Paper No. 5 |
| 5S9W-35bddl | 207.03 | -38 | -42 | -4 | Int. Paper No. 4 |
| 5S10W-16dbdl | 300 | 73 | 76 | +3 | Whitehall P.S. No.1 |
| 6S7W-33dddl | 195 | 54 | 52 | -2 | Linwood School |
| 6S8W-10cacl | 202.65 | -15 | -18 | -3 | Int. Paper No. 1 |
| 6S8W-16cccl | 202.42 | -12 | -14 | -2 | Int. Paper No. 3 |
| 6S8W-25adcl | 203.48 | 24 | 22 | -2 | Int. Paper No. 2 |
| 6S8W-30aaal | 205.37 | 8 | 3 | -5 | USGS Recorder |
| 6S9W-17ccal | 234.34 | 6 | 3 | -2 | General Waterworks |
| 6S10W-22caal | 265 | 63 | 62 | -1 | General Waterworks |
| 7S7W-24babl | 118 | 70 | 68 | -2 | Tamo P.S. |

* Wells are used alternately at six-month intervals.

Source: U.S. Geological Survey, 1972 and 1973.

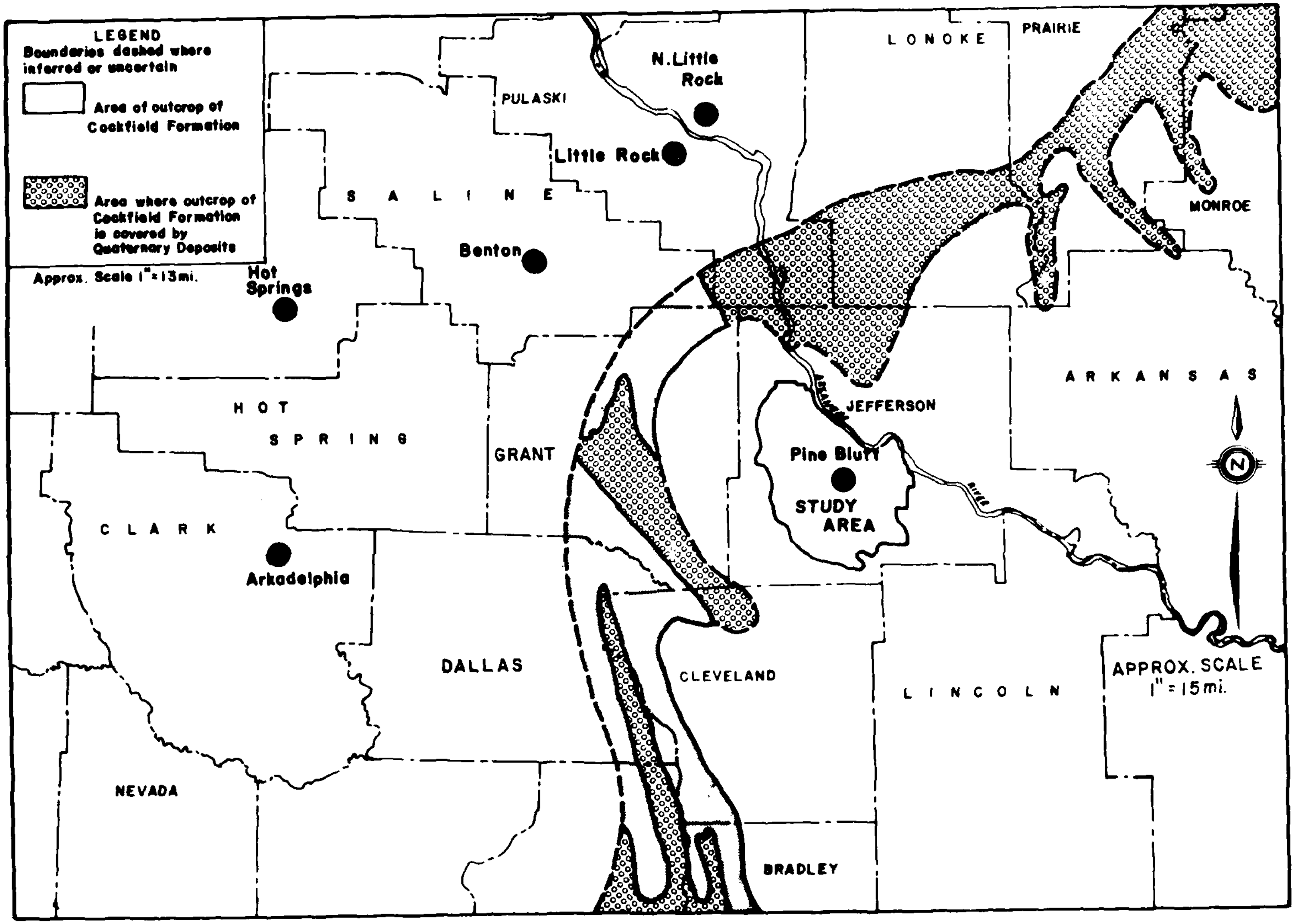



FIGURE II-16: AREA OF OUTCROP & RECHARGE OF COCKFIELD FORMATION

Source: Hosman et al., 1968.

The water in wells tapping the basal part of the Quaternary strata generally occur under artesian conditions. Non-artesian water-table conditions may, however, occur locally as a result of heavy withdrawal where the aquifer is in good hydraulic connection with streams and/or in areas where the surface alluvial deposits are permeable (Broom and Reed, 1973). Table II-11 lists the major wells in the Pine Bluff Study Area that withdraw water from the Quaternary Aquifer System.

Use of water from the Quaternary deposits began with rice farming and has now extended into row-crop irrigation, fish farming and industry. Currently (1970), 51.6 MGD or 46 per cent of the total ground water withdrawn in Jefferson County is from the Quaternary deposits (Halberg, 1972).

Tests for transmissivity and storage were reported by Broom and Reed (1973). The transmissivity (T) values of the Quaternary aquifer ranged from 13,000 to 40,000 gallons per day per foot. The coefficient of storage (S) for this aquifer averaged 0.002. All of the S values fell in the range of artesian conditions. That is, the water table or potentiometric surface is higher than the top of the aquifer.

The head distribution in the aquifer for the Study Area and vicinity (1970) is presented in Figures II-17 and II-18 as potentiometric surface maps. The measurements made by Broom and Reed (1973) were made shortly before and after the seasonal irrigation pumping. The general slope of the potentiometric surface is southward and ground water flow is either southwestward or southeastward. Figures II-17 and II-18 also indicate that in both seasons (spring and fall) Bayou Bartholomew is a drain for aquifer flow from the west and a recharge sources for the aquifer to the east. The Arkansas River upstream of Lock and Dam No. 2 is also a major recharge area (Broom and Reed, 1973). Both south and east of the Study Area, in Lincoln and Arkansas counties, moderate to extensive cones of depression have formed as a result of local heavy withdrawals (Broom and Reed, 1973; Counts and Engler, 1954). The cone of depression in Arkansas County has been in evidence since 1938 (Counts and Engler, 1954).

Although there is still much to be learned, an electrical-analog model, where flow and storage of electricity is used to simulate the flow and storage of ground water, has been established by Broom and Reed (1973) for the Bartholomew alluvial aquifer-stream system. The salient findings of this study, which is still in progress, are reported below. At the onset it should be cautioned that model data are at best only an approximation of field conditions. Moreover, variables considered negligible in the establishment of the model may well prove to be of major significance in later field studies. Finally, the model of Broom and Reed considered the entire Bartholomew sub-basin of which only a small section extends into Jefferson County and the Pine Bluff Study Area.

Model estimates of water interflow between the aquifer and Bayou Bartholomew for 1970 indicate that the bayou serves as a source of recharge in the spring and a drain in the fall. However, in the upper reaches of the bayou in Jefferson County the spring contribution was minimal. The net recharge for the entire system was estimated at 26,000 acre-feet in the spring and the net discharge at 79,000 acre-feet in the fall. The average of these values gives about 27,000 acre-feet of aquifer discharge. For Jefferson County the extrapolated average discharge into Bayou Bartholomew was approximately 300 acre-feet (200 acre-feet of spring recharge; 100 acre-feet of fall discharge).

Table II-11
Major Quaternary Water Wells in the Pine Bluff Study Area
(see Figure II-13)

| MAP CODE | LOCATION (Section-Township-Range) | DEPTH BELOW LAND SURFACE (FEET) | REPORTED DAILY WITHDRAWAL (GALLONS PER DAY) |
|---|---|---|---|
| 1 | 8-T6S-R8W | 163 | 1,821,200 |
| 2 | 8-T6S-R8W | 170 | 2,003,320 |
| 3 | 9-T6S-R8W | 159 | 1,320,370 |
| 4 | 9-T6S-R8W | 173 | 1,320,370 |
| 5 | 9-T6S-R8W | 160 | 1,456,960 |
| TOTAL | | | 7,922,220 |

Source: U.S. Army Corps of Engineers, pers. comm.;
General Water Works, pers. comm.

Table II-12
Analog Model of Water Balance
For the Bartholomew Alluvial Aquifer System*

| | | |
|---|---|---|
| DISCHARGE: | | |
| To Streams | | 27,000 |
| Underflow to Louisiana | | 20,000 |
| Pumpage | | 186,000 |
| | TOTAL | 233,000 |
| RECHARGE: | | |
| Capture plus Recharge from Rainfall & Infiltration of Irrigation Water | | 161,000 |
| CHANGE IN AQUIFER STORAGE: | | |
| Recharge Minus Discharge | | (-72,000) |

* Volumes shown in acre-feet.

Source: Broom and Reed, 1973.

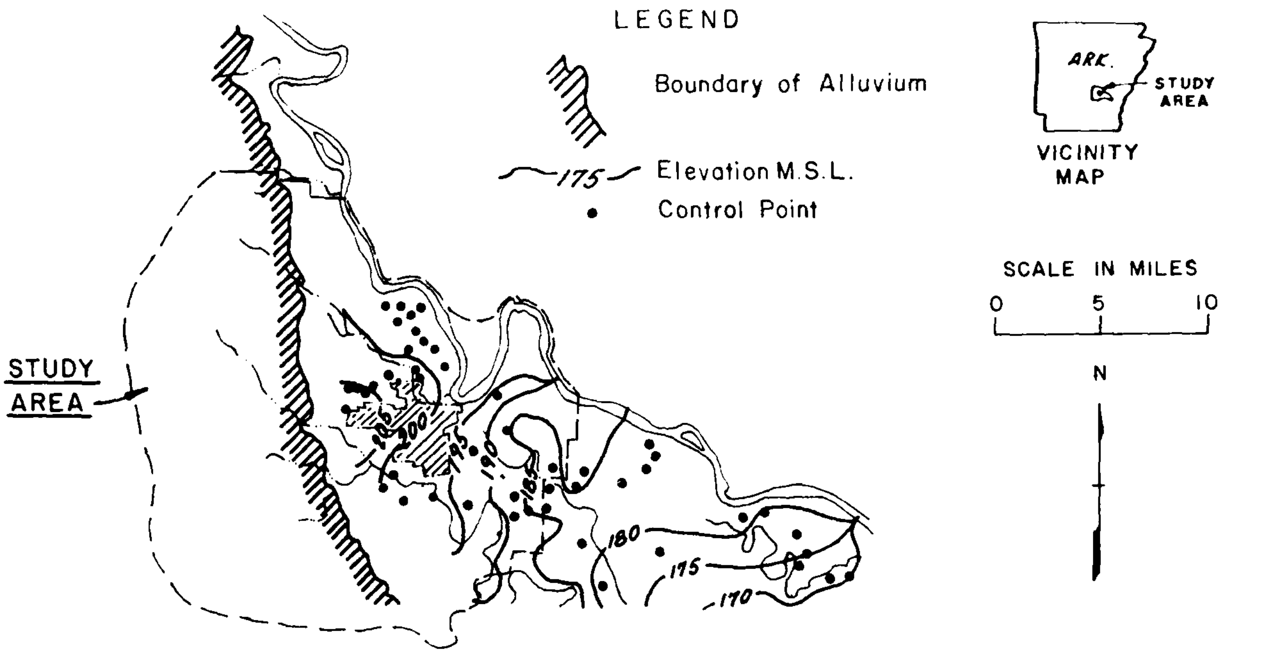



FIGURE II-17: POTENTIOMETRIC SURFACE OF THE ALLUVIAL AQUIFER - SPRING 1970

Source: Broom and Reed, 1973.

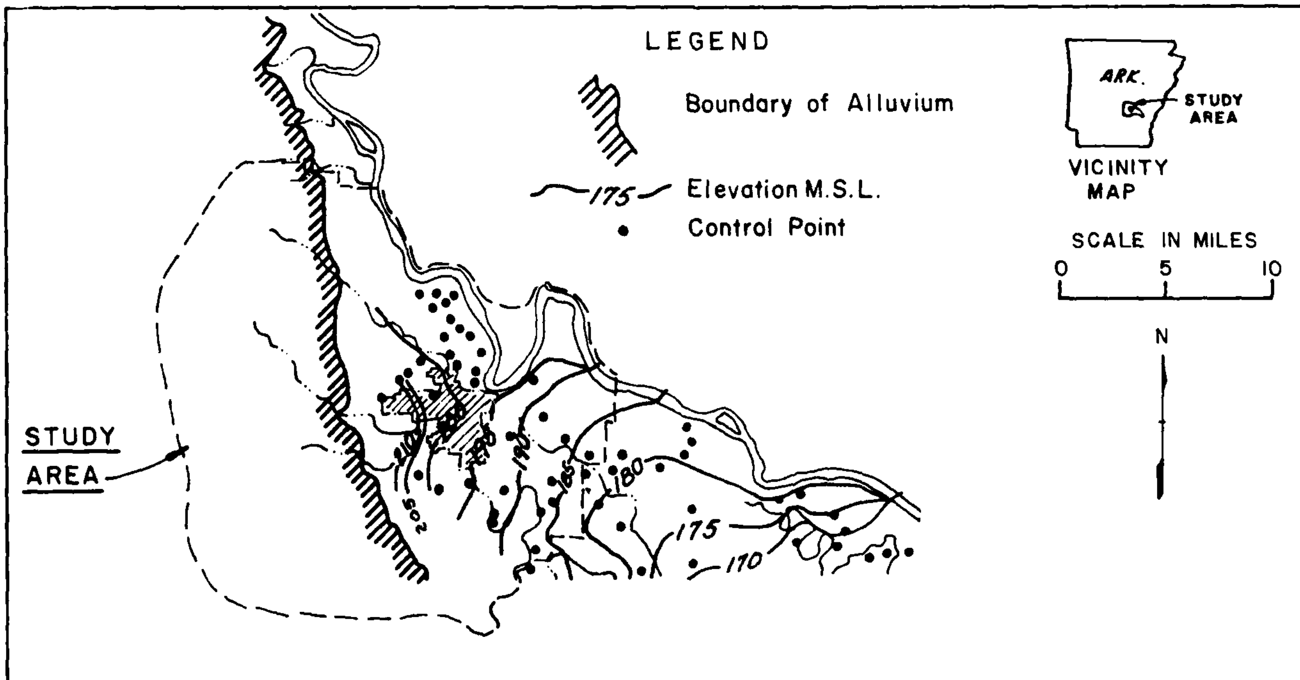



FIGURE II-18: POTENTIOMETRIC SURFACE OF THE ALLUVIAL AQUIFER - FALL 1970

Source: Broom and Reed, 1973.

A separate analysis was conducted on the effects of pumpage on the water levels in the aquifer and on stream flow. Total capture (decreased natural discharge plus increased recharge of an aquifer) was 114,500 acre-feet for 1970 (about 44,000 acre-feet for Bayou Bartholomew alone and 4,900 acre-feet for the bayou's upper reaches in Jefferson County). Given the excess of discharge over recharge after pumping as indicated above, the data suggest that most capture from the streams was that of salvaged or arrested discharge rather than induced recharge. The capture on Bayou Bartholomew was large and amounted to nearly 40 per cent of the total. In the upper reaches of Bayou Bartholomew within the Study Area, small withdrawals and/or poor connection to the aquifer resulted in little apparent capture.

For the system in its entirety, the current annual ground water pumpage is 186,000 acre-feet. As only 60 per cent of this pumpage is captured, storage within the aquifer is declining and will be followed by a concomitant decrease in stream flow as the system flow attempts to establish equilibrium.

Table II-12 provides the approximate water balance as derived from the analog analysis for 1970. The aquifer storage reduction of 72,000 acre-feet compared well with observed ground water levels in the spring of 1970 and the spring of 1971.

Stream flow diversions and return flows are shown in Table II-13. The estimated capture from Bayou Bartholomew (44,000 acre-feet) represented only 75 per cent of the total diversion from the bayou. On this Broom and Reed (1973) state the following: "At the current rate of ground water pumpage, the bayou (Bartholomew) will cease to be a perennial stream in its upper reaches. The scant flow in the bayou along the reach of greatest ground water pumpage supports this estimate."

c. Relationships of Ground Water to the Study Area.

Ground water is the major source of water for the varied and growing demands in Jefferson County and the Pine Bluff Study Area. The Study Area has adequate ground water resources to meet present and projected future water demands, however, unanticipated large-scale ground water withdrawals may occur as a result of increased pumping which may seriously lessen the possibility for increased pumpages in the future.

The ground water withdrawals are primarily from the alluvial deposits of the Quaternary Aquifer System and the Sparta Sand Formation of the Eocene Aquifer System. The Quaternary deposits supply most of the ground water used for irrigation and fish farming. The Quaternary aquifer is recharged primarily by hydraulic connections to overlying deposits in the northern and western portions of Jefferson County and to the east by Bayou Bartholomew and the Arkansas River. Moreover, the Quaternary aquifer discharges into Bayou Bartholomew from the west and is a source of its baseflow.

The Sparta Sand furnishes most of the water needed by industry and public-supply systems. Recharge to the Sparta Sand aquifer occurs by rainfall and streams in western Grant County and southeastern Selene County. Both areas are rural in character and there is no anticipated urban development or other infringements to the quality of the recharge area.

Table II-13

Streamflow Diversions and Return Flow in 1970
for Three Southeast Arkansas Streams

| STREAMS | (1) DIVERSION FROM STREAMS IN THE BARTHOLOMEW SUB-BASIN (ACRE-FT.) | (2) TOTAL WATER USE (ACRE-FT.) | (3) WATER FROM AQUIFER STORAGE & CAPTURE FROM OUTSIDE THE BARTHOLOMEW SUB-BASIN (ACRE-FT.) (COLUMN 2 MINUS 1) | RETURN FLOW FROM IRRIGATION & FISHPONDS (ACRES-FT.) | NET LOSS TO STREAMFLOW IN BARTHOLOMEW SUB-BASIN (ACRE-FT.) |
|---|---|---|---|---|---|
| Bayou Bartholomew | 55,400 | 74,600 | 19,200 | 18,700 | 36,700 |
| Boeuf River | 32,900 | 92,800 | 59,900 | 23,200 | 9,700 |
| Bayou Macon | 24,300 | 69,200 | 44,900 | 17,300 | 7,000 |
| TOTAL | 112,600 | 236,600 | 124,000 | 59,200 | 53,400 |

Source: Broom and Reed, 1973.

Because of the interaction between Bayou Bartholomew, the Arkansas River and the shallow Quaternary system, surface water and ground water have a number of potential interrelationships. Studies in 1973, by Broom and Reed, tentatively indicate that increased downstream pumpage will capture much of the potential aquifer's discharge and thus reduce flows within the bayou, particularly in its upper reaches. This could result in the elimination of much of the aquatic-oriented life associated with the upper reaches. Although quality of the Quaternary system does not currently show degradation, increased pollution loading of Bayou Bartholomew could potentially alter the water quality of the shallow aquifer. Given proposed guidelines by the Environmental Protection Agency, the consequences of a polluted Quaternary system could be bad. Irrigation of crops with waters containing high fecal bacteria or other pathogens would be prohibitive. Stockponds and fish ponds would also be forced to treat the pumped Quaternary waters.

Increased ground water withdrawal could result in reducing the level of the water table which would cause the loss of some vegetation. Those plants whose root systems extend into the surface water table and receive most of their water from that source would either die or experience reduced growth. This could possibly result in the reduction of agricultural output and the reduction of habitat for many wildlife species, as well as a reduction in the overall esthetics of the area.

In addition, although a large cone of depression has been created in the Quaternary aquifer by large industrial withdrawals in the Pine Bluff Study Area, projections of municipal and industrial use of this aquifer indicate that there will be sufficient water to supply needs through the year 2020. Even though serious declines of water levels in the Quaternary aquifer have developed elsewhere in southeastern Arkansas, within the Study Area projected uses do not indicate any serious future quantity deficit.

4. Ground and Surface Water Use and Consumption.

a. Introduction.

Changes in water use and consumption over time provide a sensitive reflection of community dynamics and agricultural trends. Because of this, an inventory and water usage analysis is a vital element at all levels of planning.

This section provides the inventory of ground and surface water use and consumption for Jefferson County. The data are based primarily on that of Halberg and Stephens (1966), Halberg (1972) and Broom and Reed (1973). In keeping with these reports, the term "use" is defined as the withdrawal of water from a source. Water usage is counted each time it is withdrawn even though, in some instances, the water is returned to a source after use. Consumed water is that portion of water used which is not immediately returned to a source and cannot be directly used again; it is water temporarily removed through evaporation, transpiration, incorporation into a product or ingestion by humans or animals. The definitions for both use and consumption are arbitrary and treat only two facets of the largely unknown and complex water budget.

b. Water Use and Consumption.

Water usage is tabulated by category of use and source for both 1965 and 1970 in Table II-14. The values are average million gallons per day; for

Table II-14
Water Usage in Jefferson County 1965 and 1970 (Million Gallons Per Day)

| USAGE | 1965 | 1970 | PER CENT INCREASE | PRINCIPAL AQUIFER OR SURFACE SOURCE |
|---|---|---|---|---|
| PUBLIC SUPPLY | | | | Drawn almost entirely from the Sparta Sand; with some western communities tapping the Jackson-Cockfield |
| Ground Water (Total) | 5.40 | 7.83 | 45.0 | |
| Commerce | 2. | 2.55 | 27.5 | |
| Surface Water | 0 | 0 | 0 | |
| TOTAL | 7.40 | 10.38 | 45.0 | |
| INDUSTRY | | | | Drawn from Sparta Sand and Quaternary |
| Ground Water | 38.96 | 51.23 | 31.5 | |
| Surface Water | 0.01 | 0.01 | 0 | |
| TOTAL | 38.97 | 51.24 | 31.5 | |
| RURAL USE | | | | |
| Domestic | | | | |
| Ground Water | 1.18 | 1.19 | 0.8 | Quaternary deposits |
| Livestock | | | | |
| Ground Water | 0.10 | 0.14 | 40.0 | Quaternary deposits |
| Surface Water | 0.14 | 0.20 | 42.9 | |
| TOTAL RURAL | 1.42 | 1.53 | 7.7 | |
| IRRIGATION | | | | |
| Rice | | | | |
| Ground Water | 27.85 | 32.08 | 15.2 | Quaternary |
| Surface Water | 0 | 1.27 | 0 | Bayou Bartholomew |
| TOTAL RICE | 27.85 | 33.35 | 19.7 | |
| Other Crops | | | | |
| Ground Water | 13.18 | 13.46 | 2.1 | Quaternary deposits |
| Surface Water | 3.29 | 7.09 | 115.5 | Bayou Bartholomew and Caney Bayou |
| TOTAL (OTHER) | 16.47 | 20.55 | 24.8 | |
| TOTAL IRRIGATION | 44.32 | 53.90 | 21.6 | |
| FISH FARMS | | | | |
| Ground Water | 0.22 | 5.33 | 1,322.7 | Quaternary deposits |
| Surface Water | 2.14 | 2.04 | -4.7 | |
| TOTAL | 2.36 | 7.37 | 212.3 | |
| WILDLIFE & FUEL ELECTRIC POWER | | | | |
| Ground Water | 0 | 0 | 0 | |
| Surface Water | 0 | 0 | 0 | |
| TOTAL | 0 | 0 | 0 | |
| TOTALS | | | | |
| Ground Water | 86.89 | 111.26 | 28.0 | |
| Surface | 5.58 | 10.61 | 90.1 | |
| TOTAL | 92.47 | 121.87 | 31.8 | |
| RANK IN STATE OF QUANTITY OF WATER USE | | | | |
| Ground Water | 4 | 4 | | |
| Surface Water | 21 | 19 | | |
| TOTAL | 7 | 6 | | |

Source : Adapted from Halberg and Stephens, 1966; Halberg, 1972.

example, water is withdrawn for irrigation only over the growing season but is reported as an average withdrawal for 12 months.

Jefferson County used approximately 122 million gallons per day (MGD) of ground and surface waters in 1970; a 32 per cent increase in usage from 1965. This increase mirrors both the growth of industry which began in the late 1950's and a more recent increase in catfish and minnow farming. Water consumption has also increased in Jefferson County to a high of 43.4 MGD in 1970 (Table II-15).

As indicated in earlier sections, 111 MGD or 91 per cent of the 122 MGD used daily in Jefferson County (1970) comes solely from ground water resources (Table II-14). In 1970, Jefferson County ranked third in total ground water use behind Arkansas and Lonoke counties and it is surpassed only by Union and Lonoke counties in its ratio of ground water to surface water use (Halberg, 1972). Ground water in Jefferson County is drawn principally from two aquifers: the Sparta Sands for municipal and industrial use and the Quaternary deposits for irrigation and other rural uses (Table II-16).

Surface water accounting for about 8.7 per cent of water usage is drawn primarily from the Arkansas River and Bayou Bartholomew. Caney Bayou and numerous small lakes and ponds serve as secondary sources.

(1) Public Supplies.

The major public supplier of potable water within the Study Area is General Water Works Corporation of Pine Bluff. Ranging between 4 and 8 MGD, the plant currently averages 7.8 MGD (General Waterworks, pers. comm.). The Corporation's nine wells tapping into the Sparta Sand Formation range in capacity from 0.7 to 2.2 MGD. Along with General Water Work's many domestic customers, there are about 64 industrial users. Some of these industries are presented in Table II-17 with their approximate yearly minimum and maximum utilization.

In addition to General Waterworks, several smaller communities and the Pine Bluff Arsenal maintain wells for potable water supply. These draw either from the Sparta Sands or the lower Jackson-Cockfield formations. The Arsenal maintains 12 wells varying in depth from 700 to 1,100 feet and process a maximum short term production capacity of 20.7 MGD (pers. comm.).

(2) Self-Supplied Industry.

Self-supplied industry includes not only industry but also all hospitals, institutions, military establishments and schools which maintain their own wells. The withdrawals are almost totally from the Sparta Sands. For Jefferson County, there are three major self-supplied "industries:" International Paper, The Pine Bluff Arsenal and Weyerhauser. Since 1958, these industries have been the principal users of ground water in Jefferson County (Bedinger et al., 1960). Together with minor industrial users, industry accounted for about 43 MGD or 84 per cent of the total deep well withdrawals and approximately 46 per cent of total ground water usage (calculations based on Halberg, 1972). Industries also utilize a small number of high capacity wells tapping Quaternary deposits (approximately 7.9 MGD).

Table II-15
Consumption of Water in Jefferson County and Arkansas
1970
(Million Gallons Per Day)

| COUNTY AND STATE | GROUND WATER | SURFACE WATER | TOTAL |
|---|---|---|---|
| Jefferson County | 43.41 | 8.41 | 51.82 |
| Arkansas | 942.50 | 283.36 | 1,225.86 |

Source: Halberg, 1972.

Table II-16
Jefferson County Ground Water Withdrawals by Aquifer
1965 and 1970
(Million Gallons Per Day)

| YEAR | QUATERNARY DEPOSITS | JACKSON-COCKFIELD | SPARTA SANDS | TOTAL |
|---|---|---|---|---|
| 1965 | 42.01 | 0.52 | 44.36 | 86.89 |
| 1970 | 59.5 | 0.36 | 51.4 | 111.26 |

Source: Halberg, 1972.

Table II-17

Ground Water Users in the Pine Bluff Study Area

| WATER USERS | SEASONAL RANGE MAXIMUM (MGD) | MONTH | MINIMUM (MGD) | MONTH | MGD ANNUAL AVERAGE |
|---|---|---|---|---|---|
| A. General Waterworks.[1] | | | | | |
| 1. Industries. | | | | | |
| a. Valmac Industries, Inc. | 0.663 | Jun. | 0.009 | Mar. | 0.508 |
| b. Central Transformer Corporation | 0.216 | Jan. | 0.076 | Jul. | 0.151 |
| c. St. Louis Southwestern Railroad | 0.117 | Sept. | 0.041 | Feb. | 0.079 |
| d. Dr. Pepper Bottling Company | 0.068 | Aug. | 0.029 | May | 0.055 |
| e. Coca Cola Bottling Company | 0.054 | Dec. | 0.031 | Jan. | 0.046 |
| f. Ben Pearson-Brunswick Division | 0.079 | Oct. | 0.018 | Mar. | 0.042 |
| g. Hudson Pulp and Paper Company | 0.044 | Aug. | 0.031 | May | 0.041 |
| h. W.S. Fox and Sons | 0.129 | May | 0.019 | Sept. | 0.038 |
| i. Illinois Tool Works | 0.045 | Mar. | 0.022 | Jan. | 0.037 |
| j. Cook Industries | 0.077 | Dec. | 0.004 | Sept. | 0.029 |
| k. Pine Bluff Sand and Gravel Company | 0.037 | May | 0.011 | Jan. | 0.028 |
| l. Arkansas Oak Flooring | 0.031 | May | 0 | Jul. | 0.025 |
| m. Standard Ice Company | 0.047 | Apr. | < 0.001 | Jan. | 0.023 |
| n. Federal Compress Company | 0.043 | Dec. | 0.006 | Jun. | 0.018 |
| o. Standard Brakeshoe Foundry | 0.023 | Aug. | 0.010 | Mar. | 0.015 |
| p. R.G. Varner Steel Products | 0.032 | Jun. | 0 | Jul. | 0.014 |
| q. Brown Manufacturing Company | 0.026 | Sept. | 0.002 | Sept. | 0.011 |
| TOTAL OF ALL INDUSTRIAL CONSUMERS | 3.324 | Aug. | 1.001 | Jun. | 1.355 |
| 2. Commercial. | | | | | |
| a. Jefferson Hospital | 0.139 | Sept. | 0.074 | Jan. | 0.118 |
| b. Pine Bluff Country Club | 0.039 | Sept. | 0.004 | Apr. | 0.019 |
| c. Arkansas Power and Light Company | 0.016 | Jul. | 0.005 | Apr. | 0.010 |
| TOTAL OF COMMERCIAL CONSUMERS | 1.579 | Aug. | 0.464 | Oct. | 1.064 |
| 3. Residential. (TOTAL) | 4.477 | Sept. | 2.465 | Jan. | 3.122 |
| B. Self-Supplied Industries. (TOTAL) | | | | | 51.0 |

1 - General Waterworks, unpublished data, 1973 and 1974.

(3) Rural Users.

Farmers and others who furnish their own water supplies almost exclusively draw from the Quaternary aquifers. The data compiled in Table II-14 were computed on the basis of 77 gallons of water per capita for all persons having running water and 20 gallons per day for those without (Halberg, 1972). About 41 per cent of the 0.34 MGD used to raise cattle, hogs, horses and poultry is drawn from wells; the remainder is supplied by surface waters, principally from small lakes and ponds. In consumption, it is assumed that 100 per cent of the water used by rural households or livestock is consumed.

(4) Irrigation.

Rice irrigation represents the major use of the withdrawals from Quaternary aquifers in Jefferson County and occurs east of the Study Area. The 32.1 MGD used in rice farming in 1970 represents 60 per cent of withdrawals from the Quaternary strata and 29 per cent of total withdrawals. Only small amounts of deep well water or surface waters are currently used in rice irrigation (U.S. Geological Survey, pers. comm.). By 1948, rice irrigation withdrawals for Jefferson County had risen to approximately 14 MGD (Klein et al., 1950). In 1953, rice-acreage controls went into effect and since that time pumpage has fluctuated according to the size of the annual rice-acreage allotment. However, rice irrigation has steadily increased since 1957 and has reached highs of 27.9 MGD in 1965 and 32.1 MGD in 1970 (Table II-14).

The application of water to rice fields averages 28 inches/acre/growing season on the western terrace and 54 inches/acre/growing season on the flood plain. These differences are attributable to: 1)efficiency of application and 2)differences in infiltration characteristics of the soil (Broom and Reed, 1973). Estimates of return to streams of applied water are about 25 per cent. Thus, 75 per cent is consumed through evapotranspiration and ground water storage. The latter is minimal with the common practice of locating rice fields on clay subsoil to minimize infiltration losses.

Irrigation of other crops is limited to cotton and soybeans in the Study Area and varies according to rainfall during the growing season. Cotton-soybean irrigation is the major user of surface waters and accounts for 67 per cent of the total surface water usage. Ground water use in "other crop" irrigation represents only 12.3 per cent of the total ground water use and 40 per cent of the total irrigation water used (based on Halberg, 1972; see Table II-14). Consumption of cotton-soybean irrigation waters is estimated at about 67 per cent (Halberg, 1972).

(5) Fish Farming.

Fish farming, principally for catfish and minnows, is becoming an increasingly important activity within Jefferson County as reflected in the increase in total water used in this category from 1965 to 1970 (Table II-14). Of this water, 71.5 per cent is supplied by wells of the Quaternary Aquifer System; the remainder from surface waters. Due to the more recent drastic increases in fish food prices, however, there has been a decrease in fish farming. There is only one significant fish farm (minnows) in the Study Area. It is located south of the City of Pine Bluff off Ohio Street.

(6) Other Uses.

Currently, electric power plants do not draw upon the waters of Jefferson County. Current plans for the White Bluff Steam Generating Plant near Redfield will, if constructed, draw from the Arkansas River. The comparatively small amounts of ground water that would be used (less than 2 MGD) for cooling would be recirculated.

# LAND USE III

# III
# LAND USE

## A. EXISTING LAND USE: FUNCTIONAL CLASSIFICATION.

The functional land use classification divides land usage into developed and non-developed uses as summarized in Table III-1 and delineated in Figure III-1. The developed uses include: residential, commercial, public, semi-public, industrial and transportation, communication and utility areas; complimenting these are agricultural lands, forests and major water bodies - undeveloped uses. A synopsis of these uses is as follows.

### 1. Residential Acreage.

An estimated 4,356 acres within the Study Area are devoted to residential use. This figure represents a density factor of 18.0 people per net residential acre in urban areas and 15.2 for non-urban areas. The 18.0 figure was developed in the 1965 Pine Bluff Urban Area Transportation Study and the 15.2, on empirical analysis. Specific statistics for the amount of land accommodating multi-family dwelling units were not available; however, according to the Southeast Arkansas Regional Planning Commission (pers. comm.), 75 per cent of the dwelling units in the Study Area are single family residences.

### 2. Commercial.

The commercial land in the Study Area is approximately 550 acres - the majority (405 acres) being located in the urbanized area of Pine Bluff.

### 3. Public.

There is an estimated 4,475 acres of land for public usage within the Study Area. Of this amount 1,749 is classified as institutional and 2,726 as recreational. The institutional areas include schools, governmental offices, and community facilities (e.g., Grider Field, health centers, city-owned maintenance facilities, etc.), and the recreational areas include all publicly owned recreational facilities and areas. This figure, 2,726 acres, also includes the 1,145-acre regional park site being developed adjacent to Lake Pine Bluff.

### 4. Semi-Public.

This category includes those areas privately owned but non-restrictive in their use (e.g., churches, private schools, cemetaries, private recreational facilities, etc.).

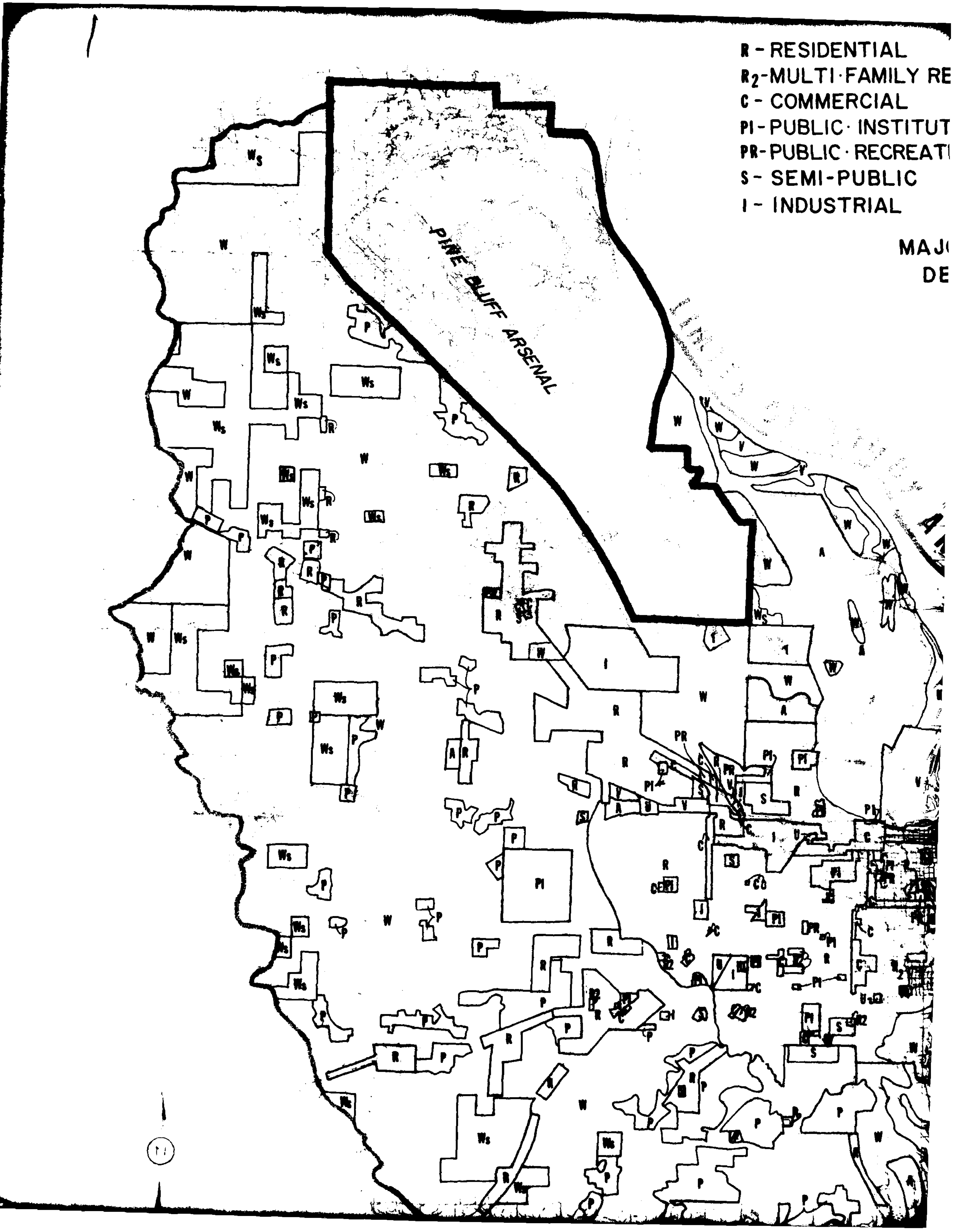
### 5. Transportation, Communications and Utilities.

This category includes all land that is being used for transportation, communication and utilities; that is, roadways, rail corridors, power generating facilities and transmission lines, pipelines, etc. Data from the 1965 "Pine Bluff Urban Area Transportation Study" were used as baseline, and supplemented with acreage statistics that would account for the new developments of this classification constructed since 1965.

TABLE III-1

EXISTING LAND USE BY FUNCTIONAL CATEGORIES
FOR THE STUDY AREA
1974

| FUNCTIONAL CATEGORY | ACREAGE | PER CENT OF STUDY AREA |
|---|---|---|
| Residential | 4,356 | 3.5 |
| Commercial | 550 | .4 |
| Public | 4,072 | 3.3 |
| Institutional | 1,749 | 1.4 |
| Recreational | 2,726 | 2.2 |
| Semi-Public | 643 | .5 |
| Trans., Comm., Utl. | 4,771 | 3.8 |
| Industrial | 4,282 | 3.4 |
| Arsenal & Related Uses | 15,000 | 12.0 |
| Agricultural | 37,075 | 29.7 |
| Cropland | 18,176 | 14.6 |
| Pasture & Clear Cuts | 18,899 | 15.1 |
| Forest Land | 46,666 | 37.5 |
| Softwoods (Managed) | 9,549 | 7.7 |
| Hardwoods (Managed) | 0 | 0.0 |
| Mixed Woods | 37,117 | 29.8 |
| Major Water Bodies | 6,982 | 5.6 |
| TOTAL | 124,800 | 100.0 |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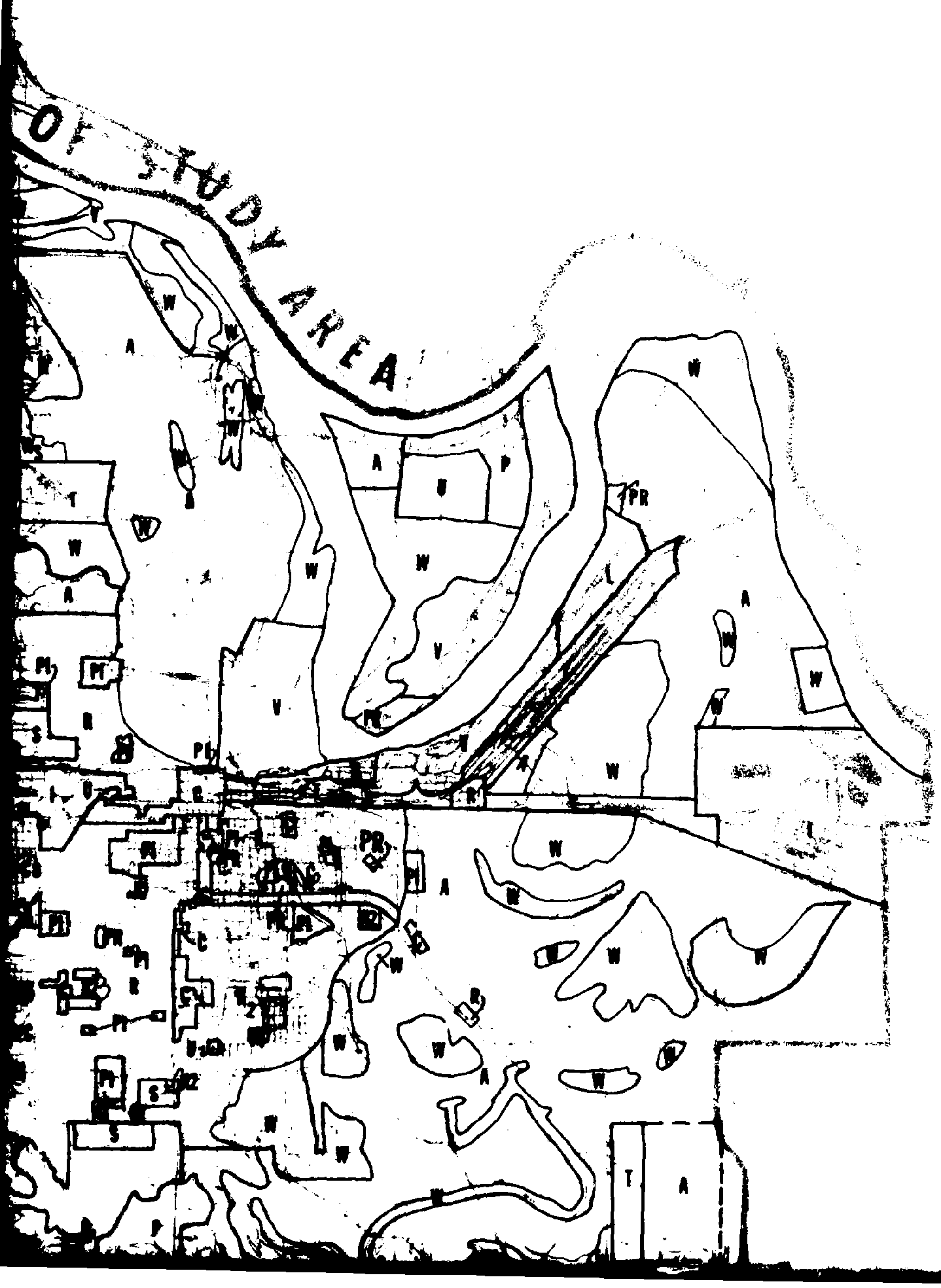
R2-MULTI·FAMILY RE
C - COMMERCIAL
PI - PUBLIC· INSTITUT
PR- PUBLIC· RECREAT
S - SEMI-PUBLIC
I - INDUSTRIAL
MAJ
DE
PINE BLUFF ARSENAL

LEGEND

| | |
|---|---|
| - RESIDENTIAL | A - AGRICULTURAL - CROPLAND |
| 2-MULTI·FAMILY RESIDENTIAL | P - PASTURE LAND |
| - COMMERCIAL | W - MIXED WOODS |
| - PUBLIC· INSTITUTIONAL | Ws-MANAGED SOFTWOOD AREA |
| - PUBLIC· RECREATIONAL | U - PUBLIC UTILITIES |
| - SEMI-PUBLIC | V - VACANT LAND |
| - INDUSTRIAL | T - TRANSPORTATION |

MAJOR WATER BODIES AS
DELINEATED ON BASE



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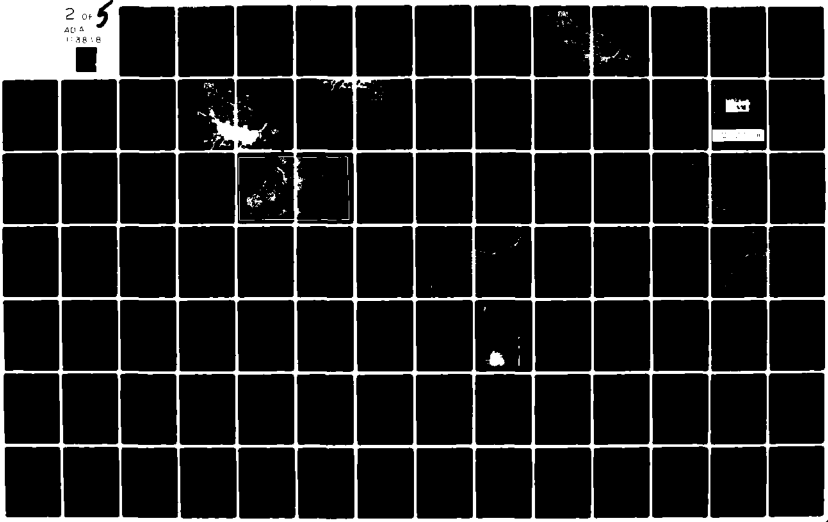
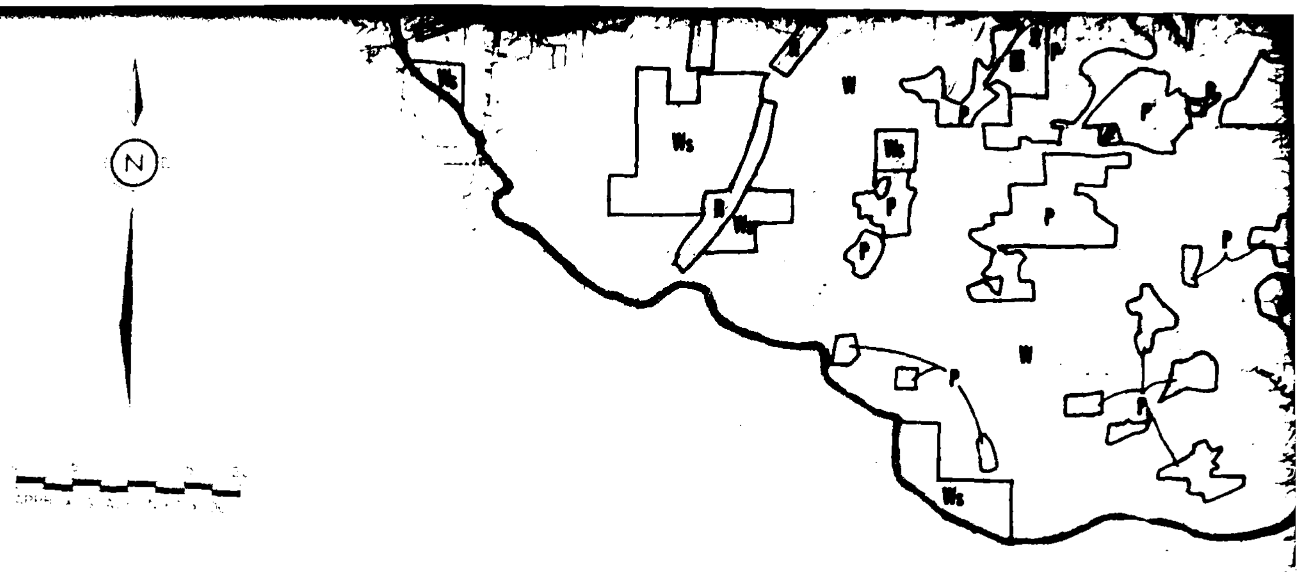
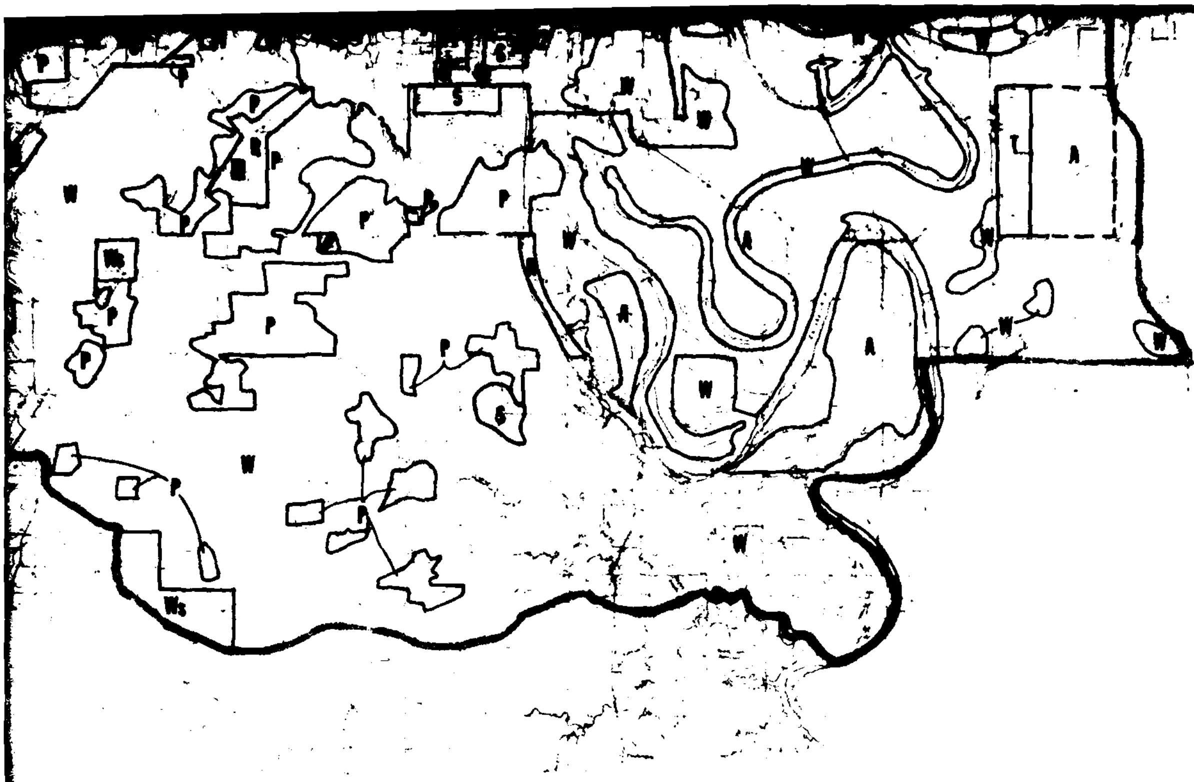





# EXISTING LAND USE
# OF THE PINE BLUFF STUDY

3




NG LAND USE
BLUFF STUDY AREA

FIG. III - 1

4

6. Industrial.

The 4,282 acres listed for this category include the 785-acre Jefferson Industrial Park and the 372-acre Harbor Industrial District as well as large industrial facilities such as International Paper Company, the Weyerhaeuser Company, etc. The majority of land in this category is held by a few major industries; however, there are many smaller facilities scattered throughout the Study Area. With the development of the Harbor and Jefferson Industrial Parks, it is anticipated that future industrial growth will be primarily in these areas. The Pine Bluff Arsenal has not been considered in this category as it has been classified separately.

7. Agriculture.

Agricultural lands were divided into crop and pasture lands of which approximately 18,176 acres were in crops and 18,899 acres were cleared and used for pasture. Because these statistics were developed from aerial photographs, clear-cut areas have been classified along with pasture lands, and some small agricultural areas (those less than five acres in size) to the west of Bayou Bartholomew were excluded.

8. Forest Lands.

Forested areas accounted for 46,666 acres of land in the Study Area. Of this total, 9,549 acres were in managed softwood areas and 37,117 acres were in areas of mixed woods. It should be noted that clear-cut areas in the managed softwood forests are shown as managed forest and, therefore, may conflict with the plant communities illustrated in Figure VI-3. Forested areas in the Arsenal are not included in Figure III-1, but are classified in the total Arsenal area.

9. Pine Bluff Arsenal.

The Arsenal and its related uses account for approximately 15,000 acres of the Study Area and represent the largest single holding in the Study Area. Due to the fact that the Arsenal is a classified area, detailed information concerning the specific usage of this 15,000-acre tract is not available for publication.

10. Major Water Bodies.

Major water bodies account for the use of 6,336 acres in the Study Area. Oxidation ponds add another 646 acres to the total surface water areas.

## B. NON-CONFORMING AND INCOMPATIBLE LAND USES.

Non-conforming and incompatible land uses often detract from the "quality of life" enjoyed by many communities. Non-conforming uses are those that do not coherently belong together and, therefore, produce deleterious effects; on

the other hand, incompatible land uses cause direct conflicts in usage and often cannot be reconciled. Examples of both non-conforming and conflicting land uses that plague the Pine Bluff area are delineated as follows.

1. Rail Corridors.

One of the more pronounced examples of incompatible land usage in the Pine Bluff area is rail corridor placement through major residential, commercial and agricultural areas. Historically, the City of Pine Bluff developed on the periphery of these rail corridors. At present, there exist 104 street rail crossings, one highway overpass and no railroad overpasses (Pine Bluff Chamber of Commerce, pers. comm.). Some adverse effects of this incompatible land use are: 1) disruption of normal daily vehicular traffic; 2) safety hazard to motorists and pedestrians; 3) noise; 4) disruption of police, fire and ambulance protection; and 5) disruption of agricultural activities.

2. Industrial and Recreational Usage of Lake Langhofer.

Lake Langhofer is a former main channel of the Arkansas River which, since the construction of the Boyd Point Cutoff Levee, now serves as a port facility and a recreational area. Barge traffic generated by the Harbor Industrial Area, and pleasure and fishing boat traffic, all use the eastern sector of the lake. Additionally, sand and gravel dredging commonly occur in this portion of Lake Langhofer.

Barge traffic passing the heavily used Island Harbor Marina and the Ste. Marie Park area constitute an incompatibility that is a potential danger to pleasure craft and swimmers. Noise and turbidity generated by large tugboats also may have a deleterious effect upon the recreational value of the lake. As the Harbor Industrial Park grows, increasing incompatibilities will exist between it and the Ste. Marie area as 1) Ste. Marie may inhibit growth of the industrial park, and 2) dangers will increase to pleasure craft as barge activity increases.

3. Runoff and Water-Contact Sports in Lake Langhofer.

The pasturing of beef cattle in the predominantly recreational areas of Boyd Point constitutes a non-conforming land usage. Pathogens carried into Lake Langhofer could constitute a health hazard to bathers and water skiers in this area.

4. Urban and Agricultural Infringement Into Greenbelt.

Sections of the proposed Bayou Bartholomew Greenbelt (see Section III E.2.c.) have been lost to agricultural pasture land and to residential/commercial activity since the proposal for the Greenbelt was made by the City of Pine Bluff in 1960. Continued development in this area will further degrade the esthetic qualities of the area. These developments, in turn, will be subjected to flooding problems.

5. Agriculture and Wildlife Management.

Soybean and cotton production invite an ever-evolving group of bacteriological, fungal, insect, avian and mammalian pests and diseases. To combat these

organisms, a variety of fungicides, herbicides and pesticides are heavily relied upon (see Section IV.C.2.). Bioconcentrations of these chemicals can result in decreased vigor or death of game, or non-game animals, depending upon the time and area of application, the longevity of the chemical, and antagonistic/synergistic reactions of the chemical in soil, water or tissues.

The infringement of agriculture into bottomland hardwood areas constitutes incompatible land usage because it reduces animal habitat and populations. The productivity of bottomland hardwoods for game species is documented in Section VI.C.

6. Stream Channelization, Flood Control and Fishery Habitats.

Channelization of stream reaches, notably those in Bayou Bartholomew west of Pine Bluff, facilitates local drainage and reduces damages to croplands. It also directly reduces fish production to one-tenth (Wharton, 1970) by increasing siltation, lowering mean stream depth, raising water temperatures and increasing water velocities. Downstream flood-prone areas become even more heavily inundated during less-intense rainfalls. Esthetic values to people-oriented activities such as fishing, camping, picnicking, and hiking are also degraded by channelization.

## C. RELATIONSHIPS OF EXISTING LAND USE TO THE STUDY AREA ENVIRONMENT.

Almost all key Study Area environmental interactions depend directly or indirectly upon land use. Land use patterns are determined by such factors as population and economic growth, private market forces, land use regulation, public services and facilities and natural topographic features and constraints. The land use patterns, in turn, impact ground and surface water, natural ground cover, runoff (urban, silvicultural and agricultural), domestic and industrial waste loads and streamflow. As illustrated in Figure III-2, water quality is impacted by land use patterns. Depending upon water quality management practices such as type, quality and quantity of wastewater disposal, feedback from water quality, in turn, impacts present and future land use patterns. As discussed in Section IV, water quality in the Pine Bluff Study Area is most heavily impacted by urban area domestic wastes and agricultural sediment. Use of area surface waters is thus limited for esthetic and recreational use, as bacterial contamination restricts primary contact sports, and sedimentation, nutrient eutrophication and increased streamflows alter biological habitats. Bayou Bartholomew, for example, can not presently be utilized for swimming due to an influx of urban and agricultural domestic wastes. Sedimentation, as noted at Station 3, alters the bayou's fishery in that area and thus affects recreational use. Land use patterns alter and/or remove environmentally sensitive areas and, in turn, impact esthetic uses such as birdwatching at Hazel Street/Bayou Bartholomew and recreation, i.e., deer and turkey hunting in commercial pine forests in the western portion of the Study Area. Land clearing increases runoff rates and results in higher velocity streamflows and downstream flooding problems, especially in agricultural areas in the eastern portion of the Study Area which have already encroached on the bayou floodplain. Urban land use can also magnify sheetflow and ponding problems in areas either unserviced by storm sewers or serviced by low-capacity systems. Future agricultural use and urban development in frequently-flooded areas is thus restricted at least partially because of existing land use patterns.

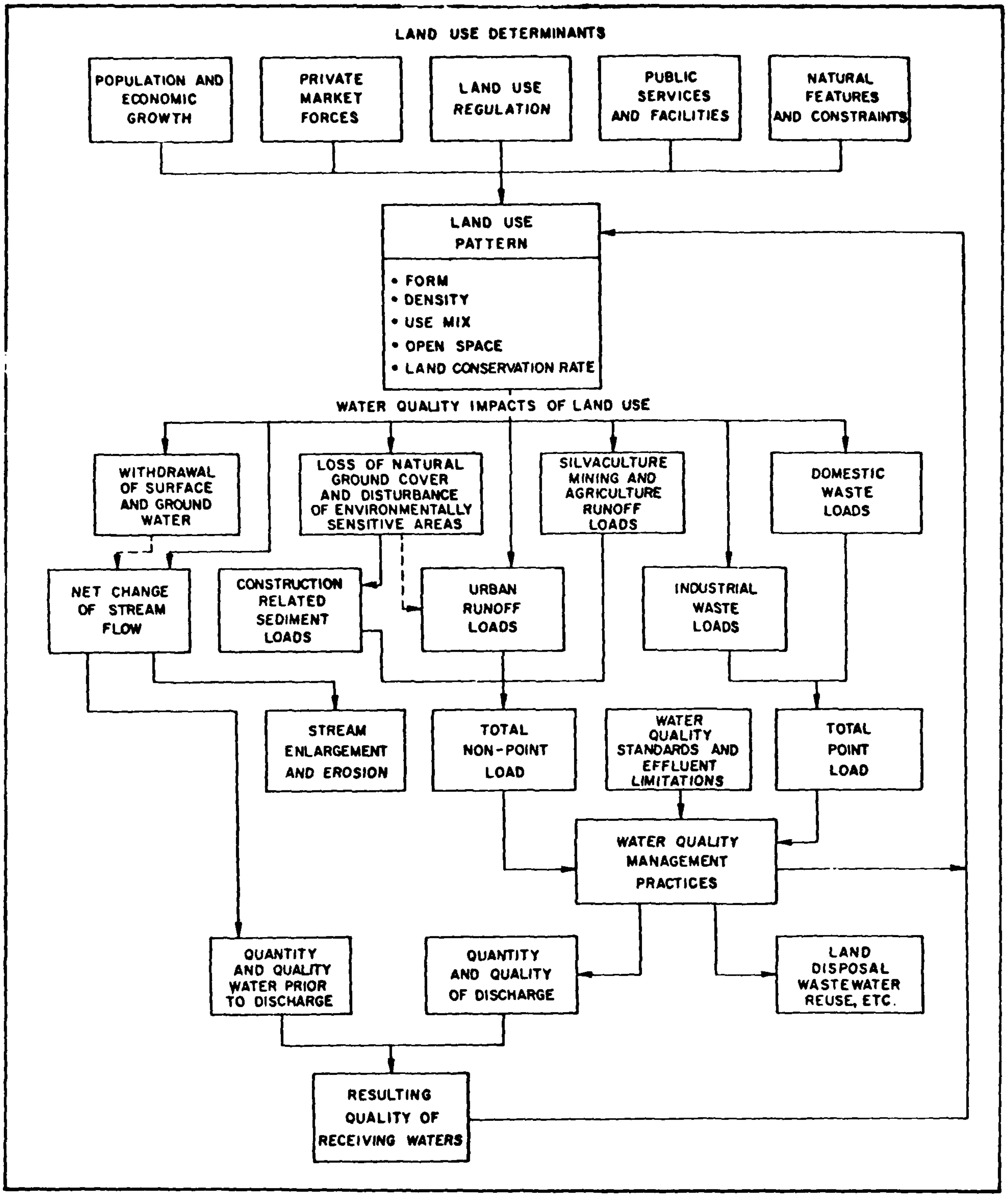



FIGURE III-2: SCHEMATIC DIAGRAM OF THE LAND USE/WATER QUALITY RELATIONSHIP

Source: Burke and Fitch, 1974.

## D. PUBLICLY HELD LANDS.

### 1. Survey of Public Lands.

Of the 124,800 acres in the Study Area, 22,198 (17.4 per cent) are publicly held. The Federal government accounts for 15,217 acres of this land and local municipalities and townships hold approximately 4,426 acres (Figure III-3).

The large Federal holdings are due to the Pine Bluff Arsenal which, together with its related uses, occupies 15,000 acres. The 4,926 acres owned by local governments represent recreational areas, schools, community facilities, and service areas. Jefferson County owns 640 acres within the Study Area and most of this land is in agricultural use.

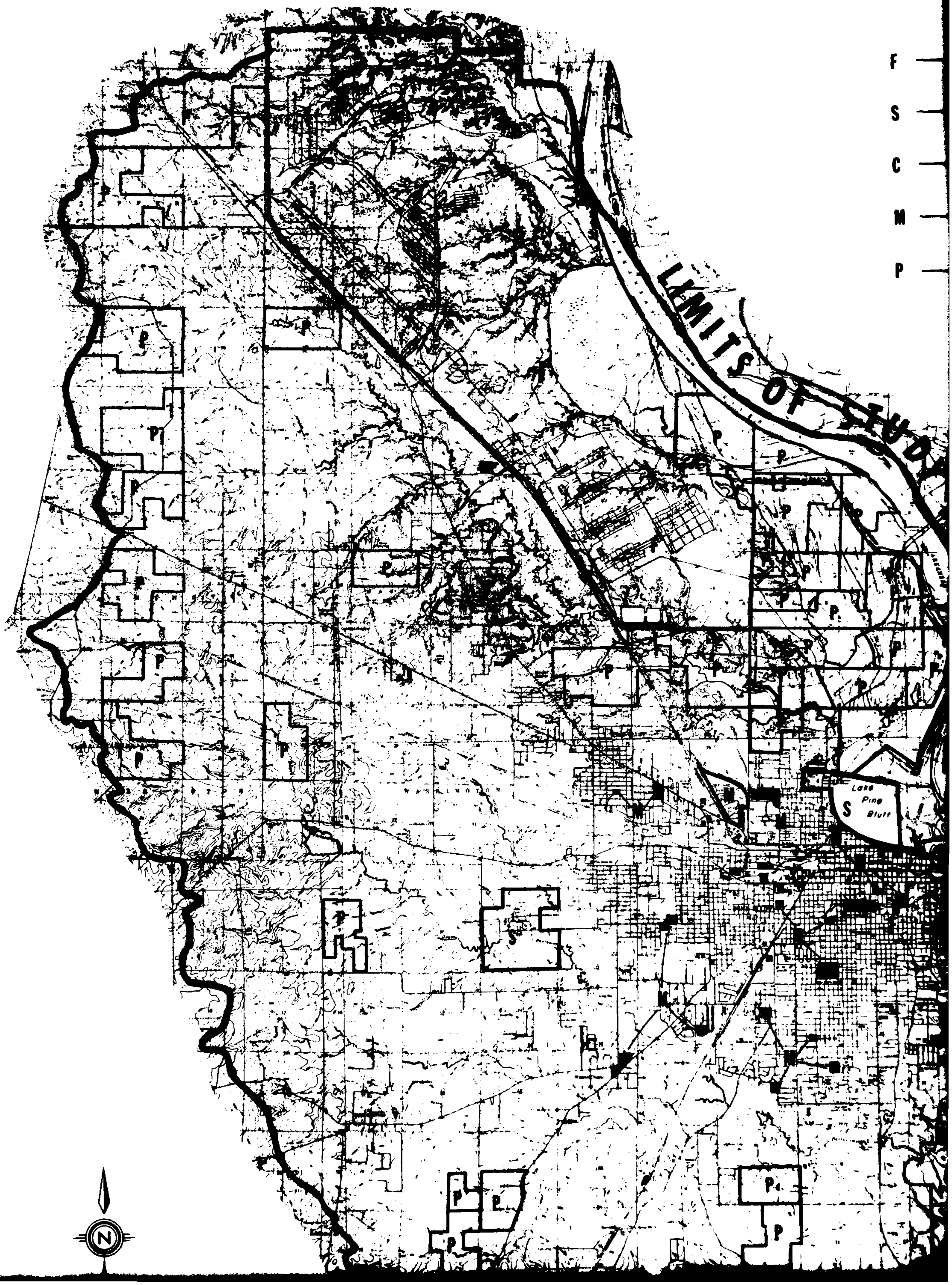
The State of Arkansas has an estimated 1,415 acres of land which are predominantly used for educational facilities.

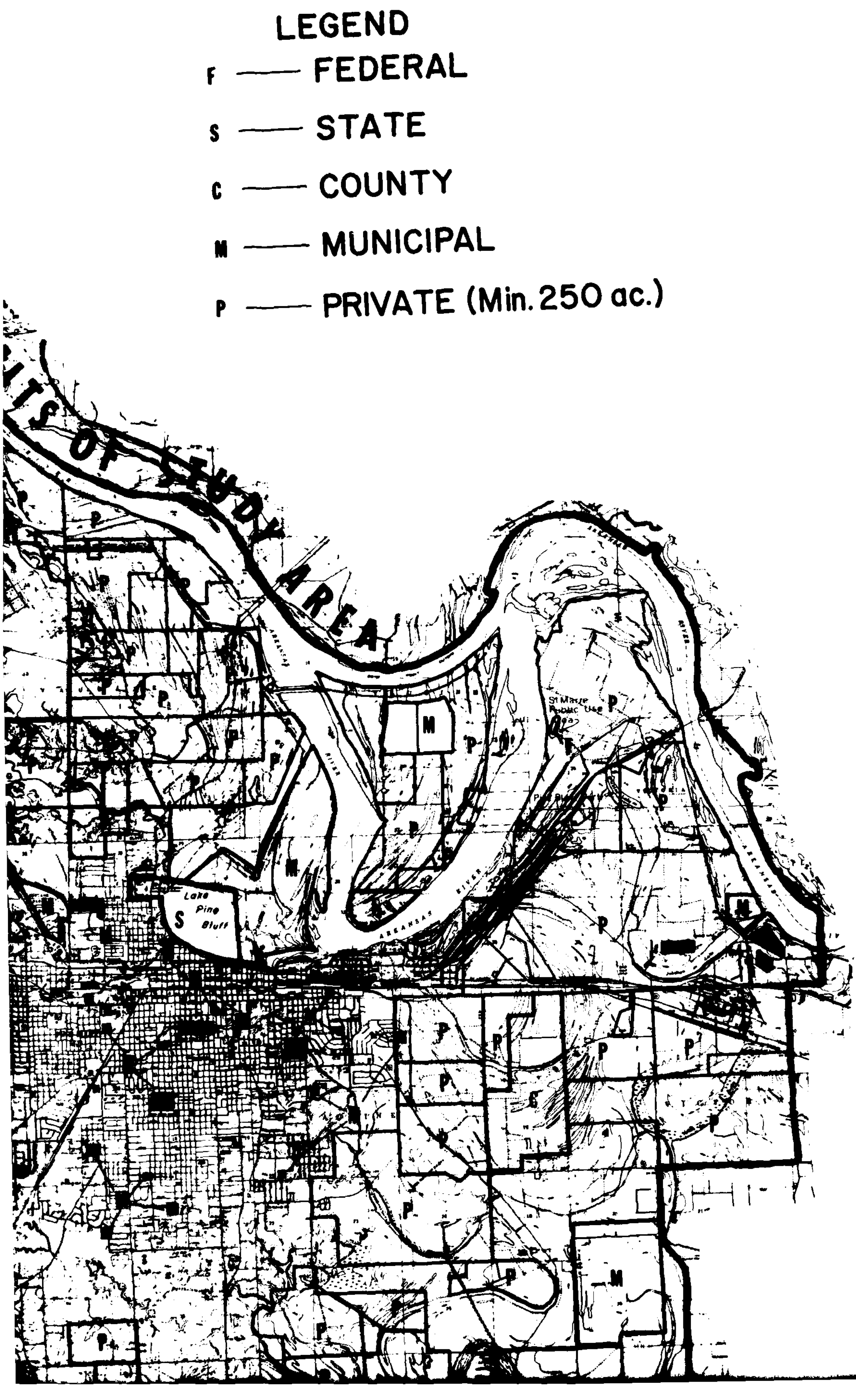
A detailed statistical breakdown of these lands is given in Table III-2.

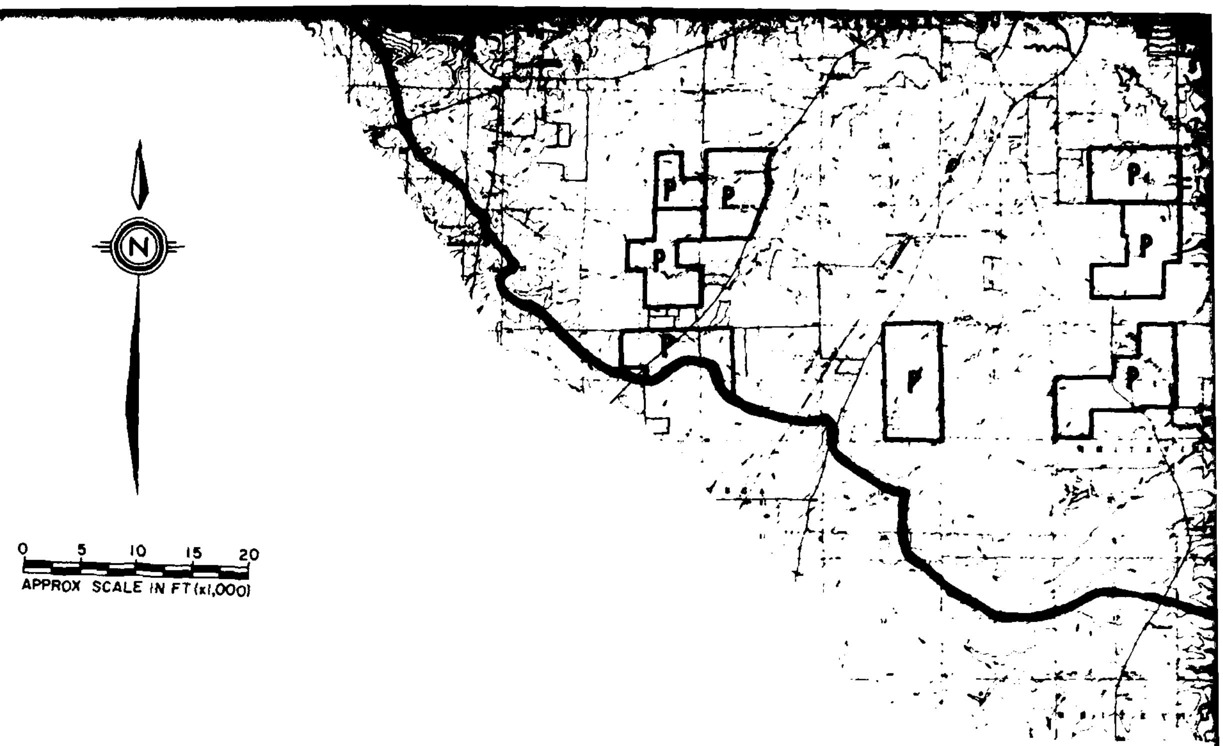
### 2. Use and Importance of Public Lands.

Public lands are often the focal points of neighborhoods and communities because they offer the local citizenry an opportunity to come together and participate in recreational, cultural and civic matters. The importance of public lands to a community can not be understated and their value should not be computed on a strict dollar basis. Two projects involving public land in Pine Bluff are the proposed recreational complex for the Lake Pine Bluff-Langhofer area and the Convention Center complex.

When fully developed, the Lake Pine Bluff-Langhofer area will add approximately 1,577 acres to the park land in Jefferson County. The responsibility for this project lies with the City of Pine Bluff's Recreation Department; implementation of the master plan for the development of this regional park has begun. A 1,145-acre tract of land in the Lake Pine Bluff-Langhofer area has been acquired and the U.S. Army Corps of Engineers has agreed to let their holdings at Boyd Point (160 acres) be included in this master park plan. The 1,145-acre tract will be developed as funds permit. This park, together with lakes Langhofer and Pine Bluff, will represent a 4,000-acre recreational area and, undoubtedly, will have the potential of being one of the finest parks in the state. This development is a part of the Master Park Plan for the City of Pine Bluff. This plan cites deficiencies in the availability of recreational areas and facilities; of particular interest to this study is the finding that there are adequate open spaces and recreational areas in the Study Area. The only deficiencies that are noted are those for neighborhood park facilities in the southern sections of Pine Bluff and for specific facilities such as baseball diamonds, tennis courts, swimming pools, etc., throughout the City. The exact locations for these neighborhood parks and recreational facilities are not given, but references are made to existing needs in the south and southwestern areas of Pine Bluff. For further information regarding this plan, consult Hodges *et al.* (1974).

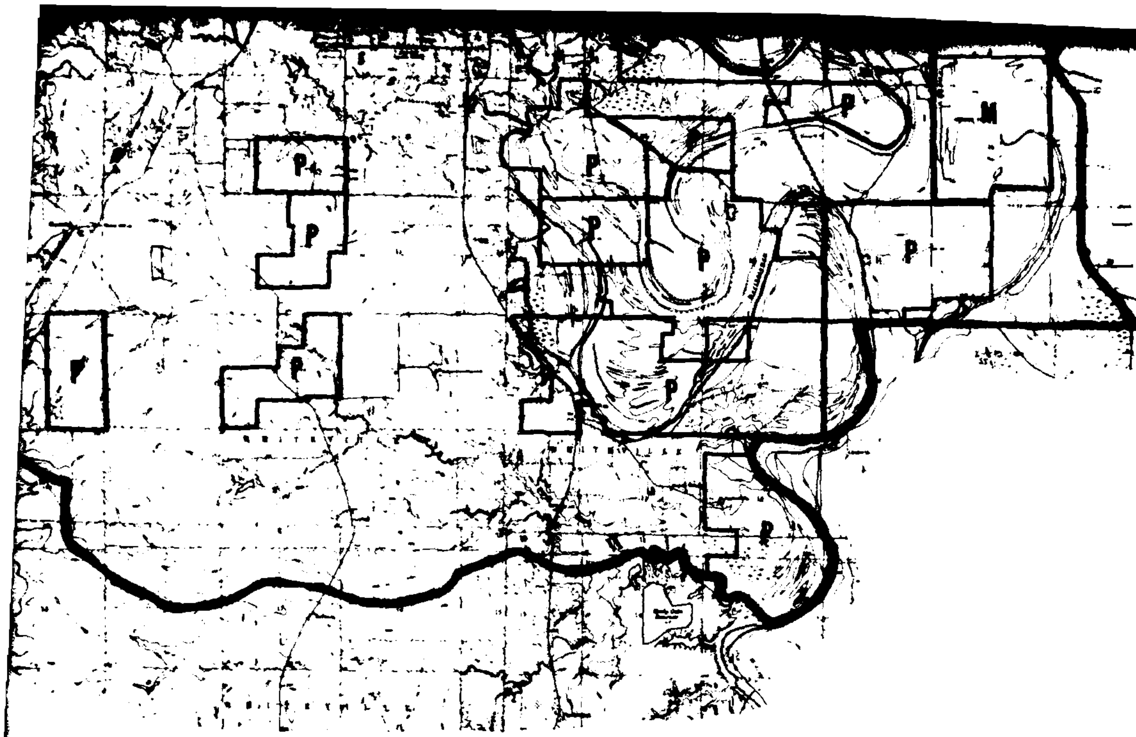

F
S
C
M
P
LIMITS OF STUDY
Lake
Pine
Bluff
S
N


LEGEND
F —— FEDERAL
S —— STATE
C —— COUNTY
M —— MUNICIPAL
P —— PRIVATE (Min. 250 ac.)
ITS OF STUDY AREA
Lake Pine Bluff




# PUBLIC AND MAJOR PRI
# LAND OWNERSHIP
# OF THE PINE BLUFF STUD

3




ND MAJOR PRIVATE
OWNERSHIP
BLUFF STUDY AREA

FIG III-3

TABLE III-2

Publicly Held Lands

in the Pine Bluff Study Area

| | ACRES | PERCENTAGE OF TOTAL STUDY AREA |
|---|---|---|
| Local Municipalities and Townships | 4,501 | 3.6 |
| Jefferson County | 640 | .5 |
| Arkansas State | 1,415 | 1.1 |
| Federal | 15,200 | 12.2 |
| Total | 21,756 | 17.4 |

TOTAL STUDY AREA: 124,800

Source: Smith Mapping Company, 1974; U.S. Army Corps of Engineers and various Pine Bluff City Officials, pers. comm.

The City of Pine Bluff is currently developing a multi-million dollar Convention Center Complex that will complement the recently completed Civic Center. The Convention Center will offer over 200,000 square feet of floor space which will include a 1,642 seat auditorium and a 4,000 seat arena. This facility will give the city the opportunity to host major conventions and trade shows and, thereby, bring new monies into the community's economy.

To date, the only known state sponsored program for the development and use of public land in the Study Area is the proposed construction of a women's prison. This prison will be located on a 40-acre tract of land adjacent to the Arkansas Industrial School. Federal programs affecting the use of public land are limited to the U.S. Army Corps of Engineers' conversion of the Boyd's Point area into a recreational facility. Boyd's Point will be incorporated into the proposed Lake Pine Bluff-Langhofer recreational complex.

## E. FUTURE LAND USE.

### 1. Projected Land Use (Functional Classification).

The projected land usage in the Study Area has been developed for the years 1985, 2000 and 2020. Baseline data were obtained from the 1974 existing land use information, and projections were formulated to coincide with the forecasted population for control years. These projections are presented in Table III-3 and a detailed methodology for the forecasting procedures is appended (Appendix B). The most important data contained in this table are the net changes in urban-type development. This statistic represents the absolute growth that is expected to be experienced during the periods between control years. Of the total growth anticipated by the year 2020, over half (53 per cent) will be experienced by 1985.

Acreage for new transportation corridors has been projected to accommodate the extension of U.S. Highway 65 in the Study Area by 1985, the construction of the Bayou Bartholomew Expressway and the relocation of the existing rail corridor by the year 2000. These projections have been separated from the transportation, communications, and utilities classification because these projects are unrelated to the forecasted trends of urban development. That is, these new corridors will be in addition to the surface roads and railways that will be required to accommodate the projected growth in the Study Area. The acreage statistic cited for transportation, communications, and utilities represents the expansion and improvement of the existing transportation system that will be needed to meet the demands of the projected population. With the exception of the statistic quoted for new transportation corridors, all projections are based upon forecasted population and do not include the consideration of specific projects.

### 2. Specific Land Use Plans.

Through contact with public and private agencies and private developers, a list of proposed projects to be developed in the Study Area was compiled and represents the future land use base. The projects were selected on the basis of their more or less "on the drawing board" planning status; they may or may not be a valid forecast. It is acknowledged that some of the following plans may never be implemented, or if they are, may be completed before or after the

TABLE III-3

Projected Land Usage by Functional Category
1974 1985 2000 2020

| | 1974 | | 1985 | | 2000 | | 2020 | |
|---|---|---|---|---|---|---|---|---|
| FUNCTIONAL CATEGORY | ACREAGE | PER CENT | ACREAGE | PER CENT | ACREAGE | PER CENT | ACREAGE | PER CENT |
| Residential | 4,356 | 3.5 | 5,431 | 4.4 | 6,059 | 4.9 | 6,454 | 5.2 |
| Commercial | 550 | .4 | 600 | .5 | 633 | .5 | 673 | .5 |
| Public | 4,072 | 3.3 | 4,773 | 3.8 | 5,100 | 4.0 | 5,320 | 4.3 |
| Institutional | 1,749 | 1.4 | 2,000 | 1.6 | 2,300 | 1.8 | 2,430 | 1.9 |
| Recreational | 2,323 | 1.9 | 2,773 | 2.2 | 2,800 | 2.2 | 2,917 | 2.3 |
| Semi-Public | 643 | .5 | 772 | .6 | 841 | .7 | 858 | .7 |
| Trans., Comm., Utl. | 4,771 | 3.8 | 5,116 | 4.1 | 5,327 | 4.3 | 5,458 | 4.4 |
| Industrial | 4,282 | 3.4 | 4,332 | 3.5 | 4,382 | 3.5 | 4,382 | 3.5 |
| Arsenal & Related Uses | 15,000 | 12.0 | 15,000 | 12.0 | 15,000 | 12.0 | 15,000 | 12.0 |
| New Transportation Corridors | - | - | 166 | .1 | 781 | .6 | 781 | .6 |
| Agricultural | 37,075 | 29.7 | 36,090 | 28.9 | 35,821 | 28.7 | 35,392 | 28.4 |
| Cropland | 18,176 | 14.6 | 18,074 | 14.5 | 17,901 | 14.3 | 18,074 | 14.5 |
| Pasture & Clear-Cuts | 18,899 | 15.1 | 18,016 | 14.4 | 17,920 | 14.4 | 17,318 | 13.9 |
| Forestland | 47,069 | 37.8 | 45,416 | 36.4 | 43,630 | 35.0 | 43,212 | 34.6 |
| Major Water Bodies | 6,982 | 5.6 | 7,104 | 5.7 | 7,226 | 5.8 | 7,270 | 5.8 |
| TOTAL | 124,800 | 100.0 | 124,800 | 100.0 | 124,800 | 100.0 | 124,800 | 100.00 |
| Net Change in Urban Type Development* | - | | 2,350 | | 1,318 | | 803 | |
| Per Cent Increase | - | | 12.6 | | 6.3 | | 3.6 | |

*NOTE: Urban-type development is considered to be the sum of Residential, Commercial, Public, Semi-Public, Trans. Comm. and Utilities, and Industrial Areas.

dates discussed in this report. Completion dates as discussed in the Transportation and Sewerage Master Plans were modified in instances where it was felt that such dates were at present unrealistic. Future urban development, extent and location were based on current population projections, current trends of development and opinions of various public and private agencies.

The following projects represent a portion of the Study Area's future land use. Although future land use projects discussed here may be developed, changed or deleted, this land use forms a base on which future environmental quality can be discussed and quantified, and if necessary, altered by interjection of new plans.

a. Railroad Relocation.

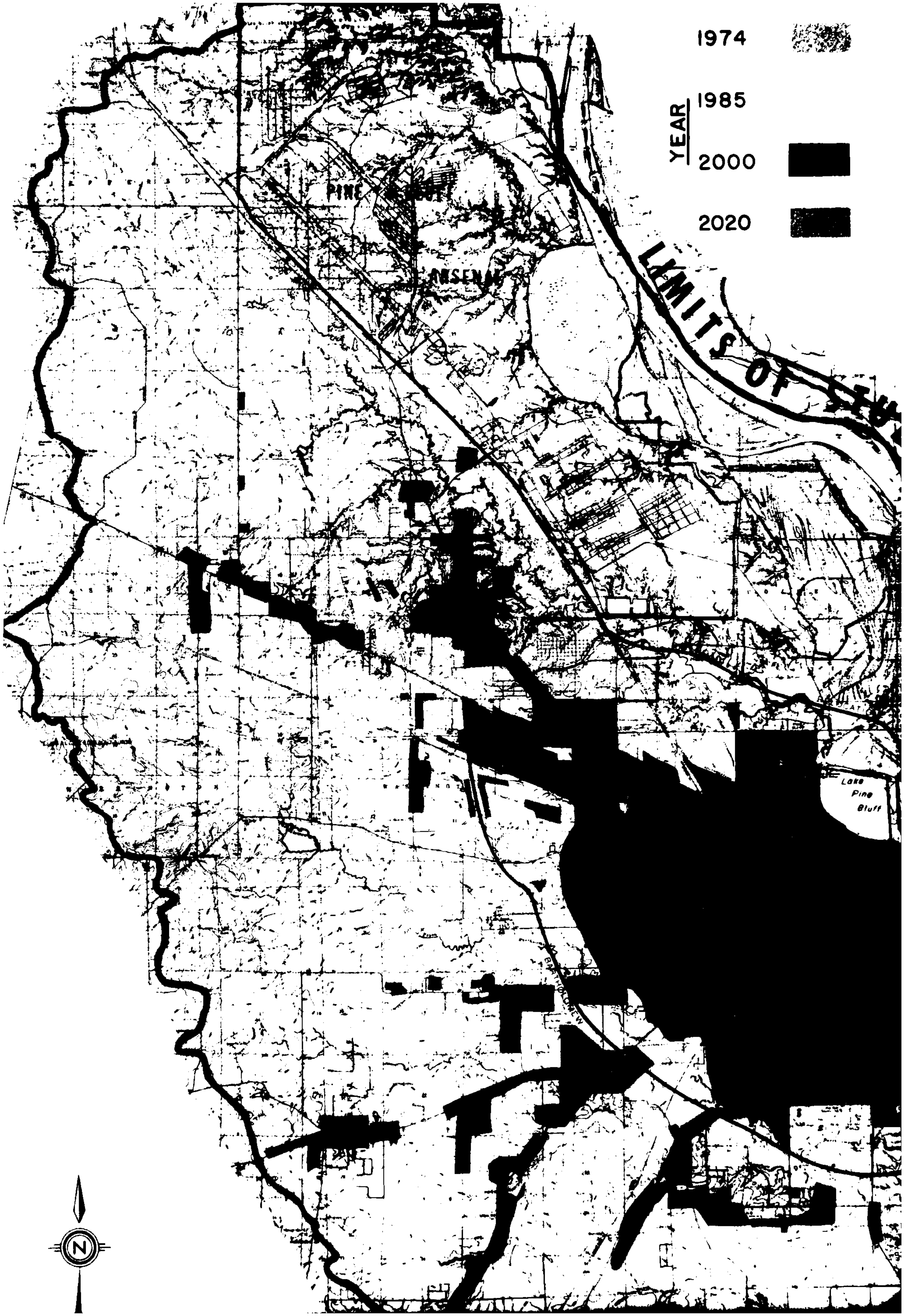
The railroad transportation system in the Pine Bluff metropolitan area is currently being analyzed for future alternatives relating to relocation of facilities. A relocation plan, tentatively approved by both the Cotton Belt and Missouri Pacific railroads, would re-route the track system 22 miles around Pine Bluff from 1/2 to two miles east and five to six miles south of the City (Figure III-4). Completion of the project is expected to occur between 1985 - 2000.

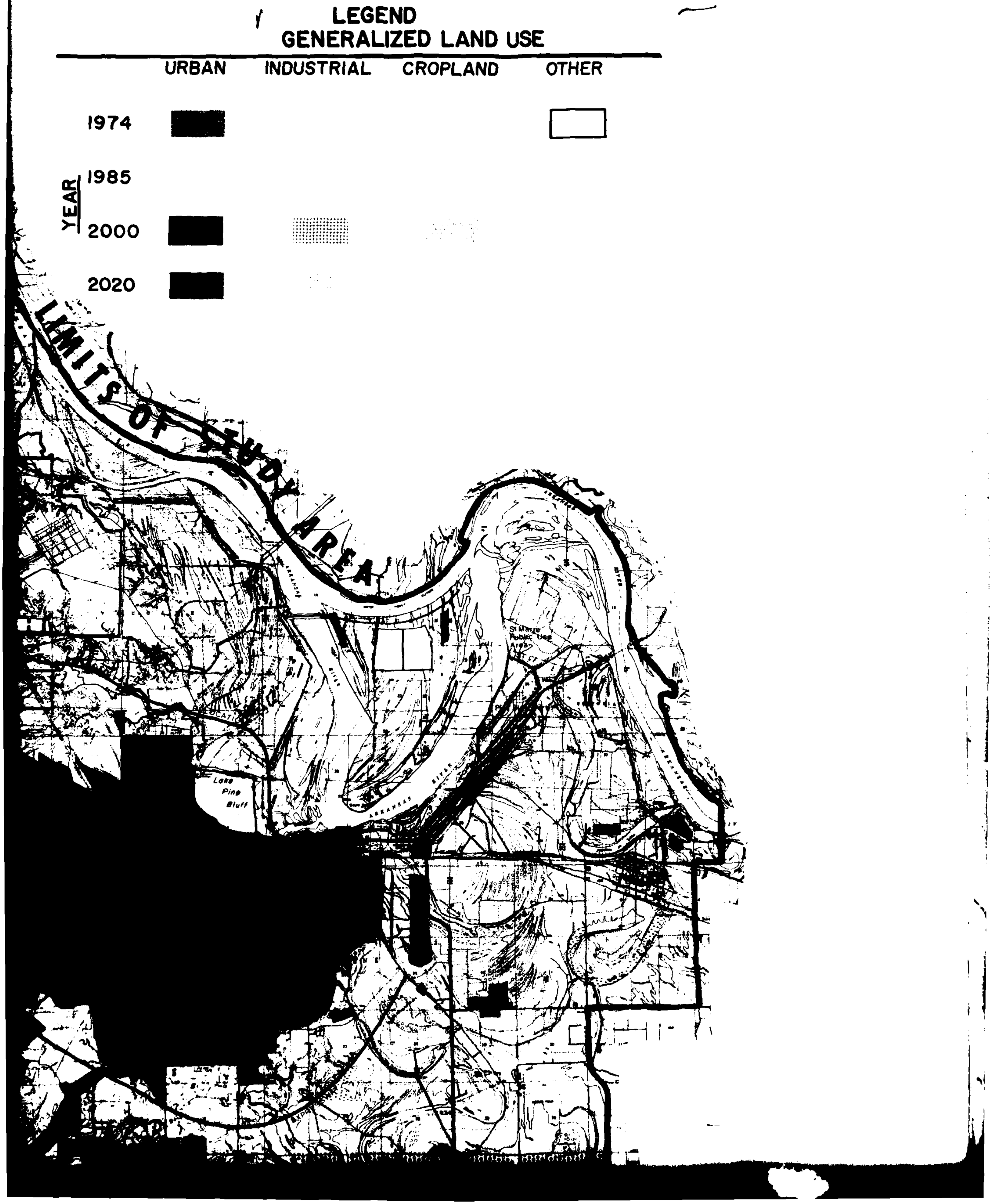
b. City Sewer System Expansion.

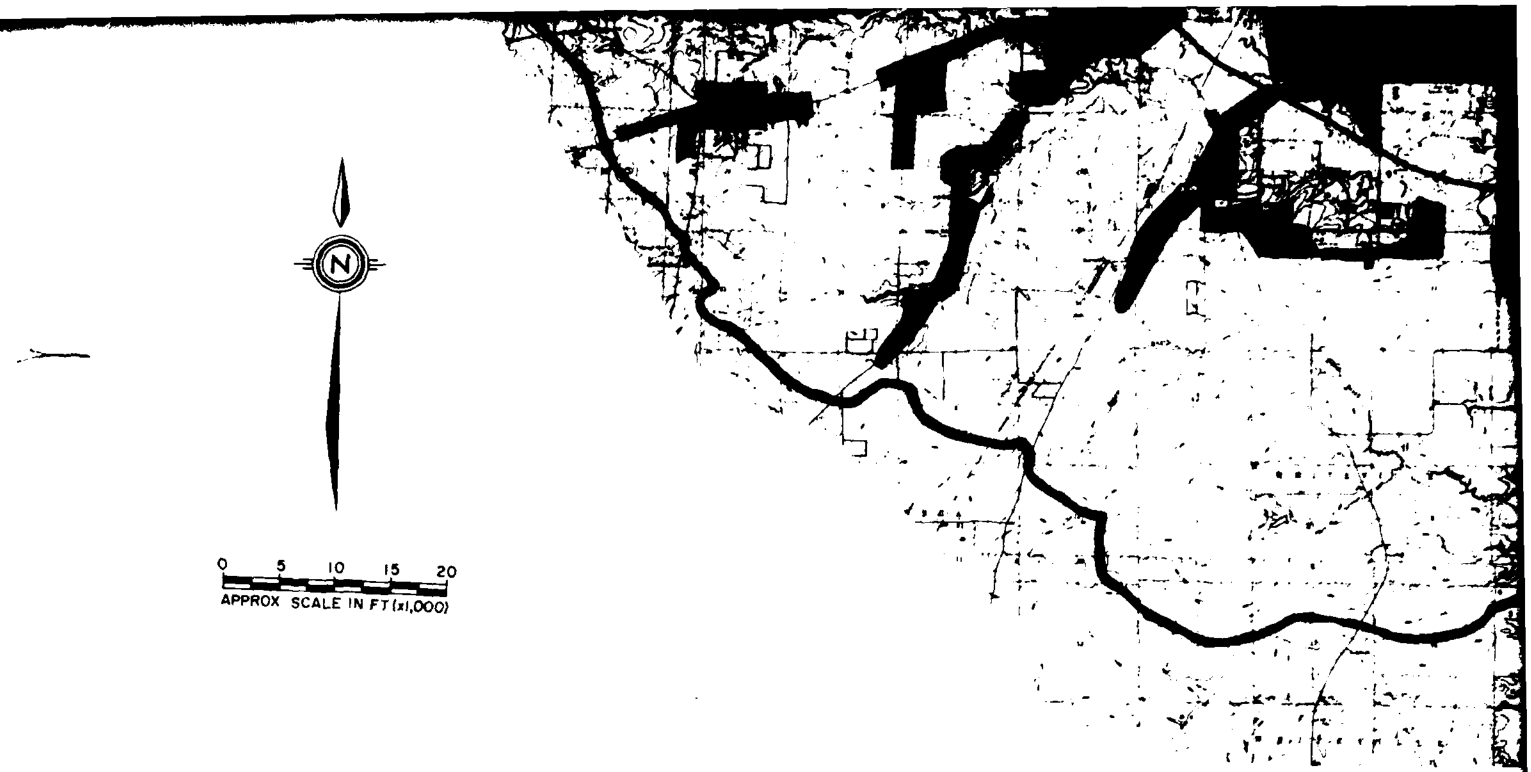
The City of Pine Bluff has been expanding its sewerage system in accordance with the Sewerage Master Plan prepared by Marion L. Crist and Associates in 1970. The plan calls for expansion of existing facilities and for the servicing of areas not presently sewered on the southeastern and western fringes of Pine Bluff. Plans for new lines and the construction of two Bayou Bartholomew stabilization ponds (Figure III-4) to be located three miles southeast of the City are at present under consideration. The Sewerage Master Plan calls for a two-step oxidation pond development, within 140 acres constructed from 1975-1980 and another 140 acres added during the 1985-1990 period. This scheduling has been revised to later dates, as other phases of the Master Plan, such as the Ohio Street collection facilities, have been running behind schedule.

c. Greenbelt.

A proposed greenbelt recreational area paralleling Bayou Bartholomew from the Missouri Pacific tracks on the west to Highway 15 on the east (Figure III-4) has been a topic of discussion since its inception in 1960. As no formal ordinance has been passed which would restrict growth into it, various developments have and will continue to occur in the area until the City of Pine Bluff either purchases land tracts or restricts development by ordinance. It is assumed that the City will purchase the land by 1985; no assumptions have been made regarding recreational or educational developments within the Greenbelt area.

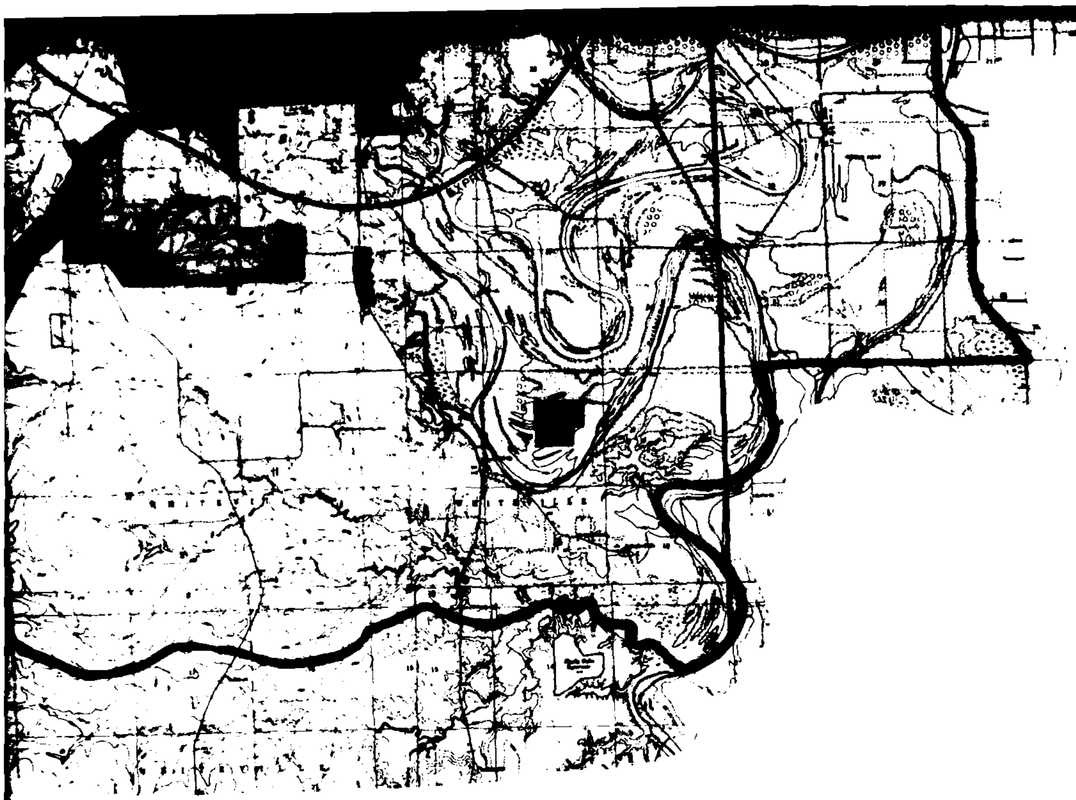

1974
YEAR
1985
2000
2020
PINE BLUFF
ARSENAL
LIMITS OF STUDY
Lake Pine Bluff


LEGEND
GENERALIZED LAND USE
URBAN
INDUSTRIAL
CROPLAND
OTHER
1974
1985
2000
2020
YEAR
LIMITS OF STUDY AREA
Lake Pine Bluff




# EXISTING AND FUTURE LAND USE OF THE PINE BLUFF STUDY AREA

3



AND USE
Y AREA

FIG. III-4

4

d. U. S. Highway 79.

(1) Pine Bluff to Camden.

A plan to expand U. S. Highway 79 to four lanes from Pine Bluff to Camden has been proposed by the Arkansas Highway Department. This corridor has been designated a principal rural artery in the 1990 National Highway Functional Classification of Needs Study.

(2) U. S. Highway 65 to Watson Chapel.

U. S. Highway 79 is to be widened and resurfaced from the U. S. 79-65 juncture to Watson Chapel, following contract letting between July 1, 1974 and June 30, 1979.

e. U. S. Highway 65.

(1) Blake Street to U. S. Highway 270; U. S. Highway 270 to Arkansas Highway 104.

Contracts for two sections of U. S. Highway 65 were awarded during the 1974 fiscal year. One section extends from Blake Street to U. S. Highway 270; the other, from U. S. Highway 270 to Arkansas Highway 104. Both sections are to be new highway locations for U. S. Highway 65.

(2) U. S. Highway 65 between Arkansas Highway 104 and Jefferson.

Grading, drainage and major structure work are scheduled for U. S. Highway 65 between Arkansas Highway 104 and Jefferson between the fiscal years 1974 and 1979.

f. Arkansas State Highway 81.

A contract will be awarded between fiscal years 1975 and 1980 for the resurfacing of Arkansas Highway 81 between U. S. Highway 65 and the Lincoln County line.

g. County Road from Pine Bluff to Port.

The Jefferson County Highway Department has indicated that the county road between Pine Bluff and the Port will be widened into a 4-lane corridor. Although no schedule has been prepared, survey work has nearly been completed.

h. 28th Avenue.

Street widening on 28th Avenue between the Missouri-Pacific Railroad and U.S. Highway 79 and overpass construction at the Missouri-Pacific juncture is currently under implementation. The project is expected to be completed in fall, 1975.

i. Bartholomew Expressway.

The 1990 Transportation Plan for Pine Bluff includes plans for an expressway paralleling Bayou Bartholomew's watercourse south and west of the city, connecting U. S. Highway 65 east and north with this route (Figure III-4). The proposed route has fallen under considerable criticism for both its close proximity to the City and its location within the 100-year floodplain. However, until other alternative routes are presented, the present plan must be considered viable (Southeast Arkansas Regional Planning Commission, pers. comm.). The completion date for this project has been tentatively scheduled for the year 2000.

j. Brumps Bayou Park.

This neighborhood park near the mouth of Brumps Bayou at Lake Pine Bluff is presently under construction and will require approximately six months to complete. The park will contain three or four footbridges crossing Brumps Bayou, three observation piers, and a 2,200-foot trail following the general course of the stream. The park consists of a narrow strip of land (2.94 acres) adjacent to the bayou.

k. Central Park Expansion.

An addition of 13 tennis courts to the existing four courts at Central Park is expected in the near future. Most of the $250,000 necessary for the expansion has been appropriated.

l. Women's Prison.

(see previous discussion in Section III.D.2.).

m. Lake Pine Bluff-Langhofer Recreational Complex.

(see previous discussion in Section III.D.2.).

n. Other Urban Expansion.

As noted in Figure III-4, a significant proportion of future urban growth is projected for the southern and southwestern fringes of the present urban area. Moderate urbanization acreages are projected for areas west and northwest of Pine Bluff, with the agricultural areas east of the city projected to urbanize only slightly.

o. Agricultural Cropland Additions and Deletions.

Wetlands in the Deep Bayou and Batholomew watershed systems east of Pine Bluff will continue to be drained for agricultural cropland use. Urban demands on agricultural lands, such as the Regional Park, and the continuing residential and commercial development east of the City of Pine Bluff will remove some croplands from productivity.

3. Consequences of Unrestrained Urban Development.

Unrestrained urban development can result in adverse environmental and economic impacts. Of principal concern, are those impacts commonly associated with suburban sprawl; the most immediate and apparent are those that are economic in nature. Spreading (random) urban-type developments require the expansion of municipal service utilities, and transportation networks, as well as the construction of new community facilities. The resulting costs often become the responsibility of the local government and citizenry as they are usually financed through the sale of municipal bonds. The incurred debt obligation is rarely retired solely by the revenues received from the expanded tax base and, therefore, must be borne by other property owners. If new facilities are not constructed, the increased use of existing facilities often diminishes their value as a communal asset.

An analysis of the economic costs associated with sprawling suburban development has recently been prepared by the Real Estate Research Corporation (1974). The report, entitled The Cost of Sprawl: Detailed Cost Analysis, delineates the economic, environmental and personal costs resulting from low, medium and high density type urban developments; however, the information is very general in nature and cannot be specifically applied to a given urban area such as Pine Bluff.

The impacts of sprawling development upon an area's environment are more subtle. The effects of urban runoff, the loss of wildlife habitat and productive agricultural lands, the loss of historically significant archeological sites, the increased levels of noise and air pollution, and the general disruption of an area's natural terrain lessen the environmental quality of the area and are often responsible for irreversible environmental damage. Appropriate measures may be taken at either municipal or county levels to prevent or mitigate the adverse impacts commonly associated with urban sprawl. Such measures would include land use, flood plain and zoning ordinances, as well as very strict and well-defined building and sanitary codes.

With the limited amount of growth that is projected for the Pine Bluff Study Area, detrimental economic and environmental consequences can be avoided with the development and institution of appropriate land use and sanitary codes. Land use controls would restrict development in environmentally sensitive areas and sanitary codes would establish minimum criteria for the disposal of sewerage, waste, refuse and garbage. If such regulations are not implemented, there will continue to be a subtle degredation of the Study Area's environmental quality.

F. Limitations to Future Land Use and Development.

1. Geology.

Structural geologic hazards in the Study Area will play an insignificant role in future plans for construction and development. As noted in Section II.B.6., Pine Bluff is located in a low seismic risk zone.

Future urban development in the Sparta Sand aquifer recharge areas illustrated by Hosman et al. (1968) could reduce infiltration into this important aquifer and potentially reduce ground water availability to Pine Bluff; however, not much urban-type development is anticipated to occur in this area.

Other limitations to Study Area future land use development are related to hydrologic and pedologic features.

2. Soils.

Engineering properties of soils can be a limiting factor in such human developments as housing, septic tanks, trafficways, industries, oxidation ponds, parks, reservoirs and dams. This section will discuss only general soils limitations extant in the Pine Bluff Study Area. Section II.C. and Appendix A should be consulted for soils limitations for various land uses, including the generalized soils map (Figure II-6). For specific projects in given areas, specific Soil Conservation Service soil maps should be consulted.

Most of the projected urban growth in the Study Area is expected to occur in three soil associations: 1) Amy-Pheba-Savannah, 2) Sawyer-Sacul-Savannah and 3) Cahaba-Savannah. Some projected recreational land uses, notably Regional Park (Figure III-4), are within the Crevasse-Portland association. The Bayou Bartholomew oxidation ponds (Figure III-4) are in an area designated as the Perry-Portland association. The proposed Bartholomew Expressway and railroad relocation routes (Figure III-4) cross a number of soil associations; because suitable roadfill is readily available in the area, soils limitations for such projects occupy low-priority levels (Arkansas Highway Department, pers. comm.).

Of the three soil associations located within projected future urban areas to the west and southwest of the present urban area, the Cahaba-Savannah is least limiting due to moderate percolation rates, slow permeability and low flood hazard. The Amy-Pheba-Savannah and Sawyer-Sacul-Savannah associations are poorly suited for highways, septic tank absorption fields and dwellings because of low strength, moderate to high shrink-swell potential, flooding hazards and slow percolation rates.

Moderate limitations to park land development exist within the Crevasse-Portland association, with high shrink-swell potentials hazardous to trafficways and building foundations. Flooding hazards in this poorly-drained association are limiting to camping and picnicking.

3. Hydrologic Limitations.

Sections of the Study Area projected to be inundated by Intermediate Regional and Standard Project floods (U. S. Army Corps of Engineers, 1973a, b) will encounter serious limitations regarding future urban development. Road and home foundations in these areas must be above Intermediate Regional flood levels; therefore, construction costs will seriously prohibit development there.

The tentative location of the future Bartholomew Expressway is mostly within the Bayou Bartholomew floodplain (Figure III-4). High construction costs in Standard Project flood areas will be a serious limiting factor to its development.

Flooding hazards of Perry-Portland soils present limitations to the proposed Bartholomew oxidation ponds; however, slow percolation rates and high shrink-swell capacities make the soils suitable for such development. Additional construction costs here would not be seriously prohibitive.

Local flooding hazards and shrink-swell soil capacities could also limit industrial growth along the proposed railroad relocation route (Figure III-4).

In agricultural areas such as those in Deep Bayou, Imbeau and Outlet sub-basins, additional draining of wetlands for cropland use is expected to continue in the future. As land and crop values rise, previous hydrologic limitations to this land use decrease. Additional agricultural development into the Bayou Bartholomew greenbelt will be severely limited due to frequent flooding hazards. If the proposed Greenbelt (Figure III-4) becomes partially utilized as a park area, then permanent structures there would have to be above Intermediate Regional flood elevations, with elevated walkways transversing low, frequently flooded areas.

Septic tank leaching will be severely limiting in many future urban areas, notably west and southwest of Pine Bluff, due to low soil percolation rates.

# SURFACE AND GROUND WATER QUALITY

# IV

# IV
# SURFACE AND GROUND WATER QUALITY

## A. INTRODUCTION.

This chapter carefully examines surface and ground water quality and the effects of many aspects of land use and activity. For clarity, surface and ground water quality are separated into distinct sections.

To fully understand the impact of the contemporary environment on aquatic systems, it is necessary to know the potential water quality of specific stream systems. Although inferences can be drawn from other stream systems of a similar geographical setting, baseline data are the only real measure of potential and are the yardstick of impact. The absence of an historical perspective is a serious shortcoming of this analysis and references to degradation of water quality must be viewed accordingly. Although degradation and pollution are commonly used descriptors, they are only judgemental.

## B. SURFACE WATER QUALITY.

### 1. General Relationships Between Land Use and Surface Water Quality.

Because of the complexities in the interrelationships of land use and water quality, an overview of some of the many ways the urban and rural environment can effect water quality has been assembled. Storm water related problems are given special attention because they dominate the impact of the Pine Bluff Study Area. Quality surface waters are an important resource and if they are to be preserved, all of man's activities and land use practices must be considered.

The quality of surface waters depends upon the continuous contributions of the drainage basin and the amplified loads induced by precipitation runoff. For the urban and rural communities of the Study Area, some of the more obvious pollutants include industrial and municipal discharges, sewage treatment plant effluents, sanitary sewer line exfiltrates, settleable air-borne particulates, irrigation waters and ground water discharges. Within the Pine Bluff Study Area points of concern include the Caney, Whitehall and Hazel Street oxidation ponds which receive partially treated effluents of various industries.

In Pine Bluff, surface water quality management has been achieved by the establishment of treatment facilities and participation in State and Federal monitoring programs. Stormwaters have been traditionally considered as only a quantitative problem and their availability has been deliberately utilized to absorb the impact of sanitary and industrial waste waters. The by-pass of sanitary waste water to storm drainage channels is not only permissable during surcharge, it is good design practice. However, stormwaters can be a major contributor to surface and subsurface water quality degradation.

Storms and stormwaters, either as direct precipitation or as snow melt impose three major water quality problems: the redistributing of existing loads such as sanitary and industrial wastes with increased water volume, the dissolving and washing-out of many toxic airborne wastes, and the scouring of complex arrays of potential pollutants from urban and rural surfaces.

Separate sanitary sewer systems are designed to collect, isolate and discharge sanitary and industrial wastes to a treatment facility based on population and other known quantities of inflow. The systems, however, are seldomly adequate to be independent of ground water infiltration and stormwater intrusion. During storm events, water can enter sewer lines from saturated soils or from manhole covers and drains to overload the design capacity and result in the discharge of raw sewage at manholes, pumping stations and other points along the system. This problem of infiltration, is particularly acute in areas of high rainfall and numerous examples are encountered in the Pine Bluff Study Area (See Section IV. B. 4).

Increased industrialization, urban development and automobile traffic in the Study Area contribute air-borne wastes which could create major health and environmental problems. In addition, significant amounts of air pollutants could enter the drainage systems and contribute to pollution problems associated with storms and stormwater runoff. Perhaps the most complex of the storm and stormwater related problems is runoff from throughout the drainage basins and the entrainment of wastes. Stormwater runoff acts as a transfer agent, transferring accumulated air and terrestrial wastes from the entire spectrum of human activities and land use practices into water wastes. Individually, none of the wastes or their sources are major when compared to municipal or industrial discharges. The community tolerates and is often oblivious to these materials even after they have accumulated on the terrestrial system over a period of weeks. However, their accumulation is gradual and well dispersed throughout the drainage basins. During runoff periods, however, the wastes are acutely concentrated and enter the receiving waters as a shock load over a period of hours. It is these temporal and spatial changes that occur during the transfer process that accord urban and rural runoff its significance as a major source of water quality deterioration.

Unlike other pollution sources in the Study Area, stormwater runoff as a diffuse, non-point source is sensitive to all land use practices within the drainage basin. Not only does urbanization and increased population enhance the potential runoff load, but the accompanying coversion of pervious open lands to impervious urban surfaces such as streets, parking lots, roofed structures, walkways and airports insures a greater quantity of runoff and faster flow rates. For the receiving stream, these hydrologic changes translate into increases in the magnitude of peak flow and the frequency of flooding. With alterations in the stream flow regime, there can be an accompanying enlargement and degradation of the stream channel. The increased amount of impervious surface coupled to the presence of organized storm drainage systems also means that only a small percentage of the potentially polluting constituents will be neutralized by open space and

that the majority will ultimately enter the receiving system. The hydraulic differences between urban and non-urban areas in the Study Area are illustrated in representative hydrographs in Appendix A (Figures A-1 through A-6).

In addition to imperviousness, other physiographic variables include slope, area, length of stream, soil characteristics and type and amount of ground cover. These variables directly determine the quantity and flow rate of runoff water and indirectly determine the kinds and amounts of waste products that will be entrained, the degree of movement within the watershed, and the availability of wastes to subsequent storm events. Closely coupled to the variables of physiography are the types and conditions of the runoff channels.

Although for planning purposes, land use is divided into residential, commercial, industrial, etc., in the interpretation of runoff quality, these subdivisions are another expression of imperviousness. More important are the physiographic and environmental characteristics and human activities of a particular land use category which together determine much of the potential pollution load. Residential and commercial areas can vary widely in their environmental conditions. Similarly, agricultural lands vary with respect to crops, soil, buffer zones, pesticide and herbicide applications and erosion control practices.

The amount, duration, intensity and distribution of the rainfall event are also key variables, but must be considered in conjunction with the elapsed time since the previous precipitation event and its characteristics in order to fully evaluate the pollution potential of a given storm. Short intervals between storms tend to ameliorate the waste loads; longer intervals accentuate them. Seasonal changes compound the complexity. Winter, with its barren fields, reduced recreational activity, increased air pollution, reduced vegetational cover and longer, less intense storms presents a markedly different runoff pollution pattern than that of summer. Factors influencing the pollution load, and the runoff and flow reaching receiving waters in the Study Area are shown in Figure IV-1.

2. Review of Previous Studies.

a. Baseflow Water Quality.

Relatively few baseflow water quality studies have been conducted in the region of southeast Arkansas. Investigations have dealt primarily with problems of industrial and municipal effluents and coliform bacteria levels in lakes and rivers. Studies that treat surface water quality of the Study Area include waste-load allocation studies for the Arkansas and Ouachita river basins (Bryant and Reed, 1974; Reed et al., 1974). They developed models of 5-year waste-load projections on the Arkansas River for four water quality parameters and computed target load projections for the tributaries. The Arkansas Department of Pollution Control and Ecology has also conducted stream surveys which included municipal and industrial effluent sampling and baseline water quality in the Arkansas River (1974a) and Bayou Bartholomew at Ladd, Arkansas (pers. comm.). The analysis of these surveys, where they are applicable to the Study Area, are reviewed in Section IV.B.4). Water quality standards for Arkansas (Arkansas Department of Pollution Control and Ecology, 1973) are presented in Section IV.B.5.

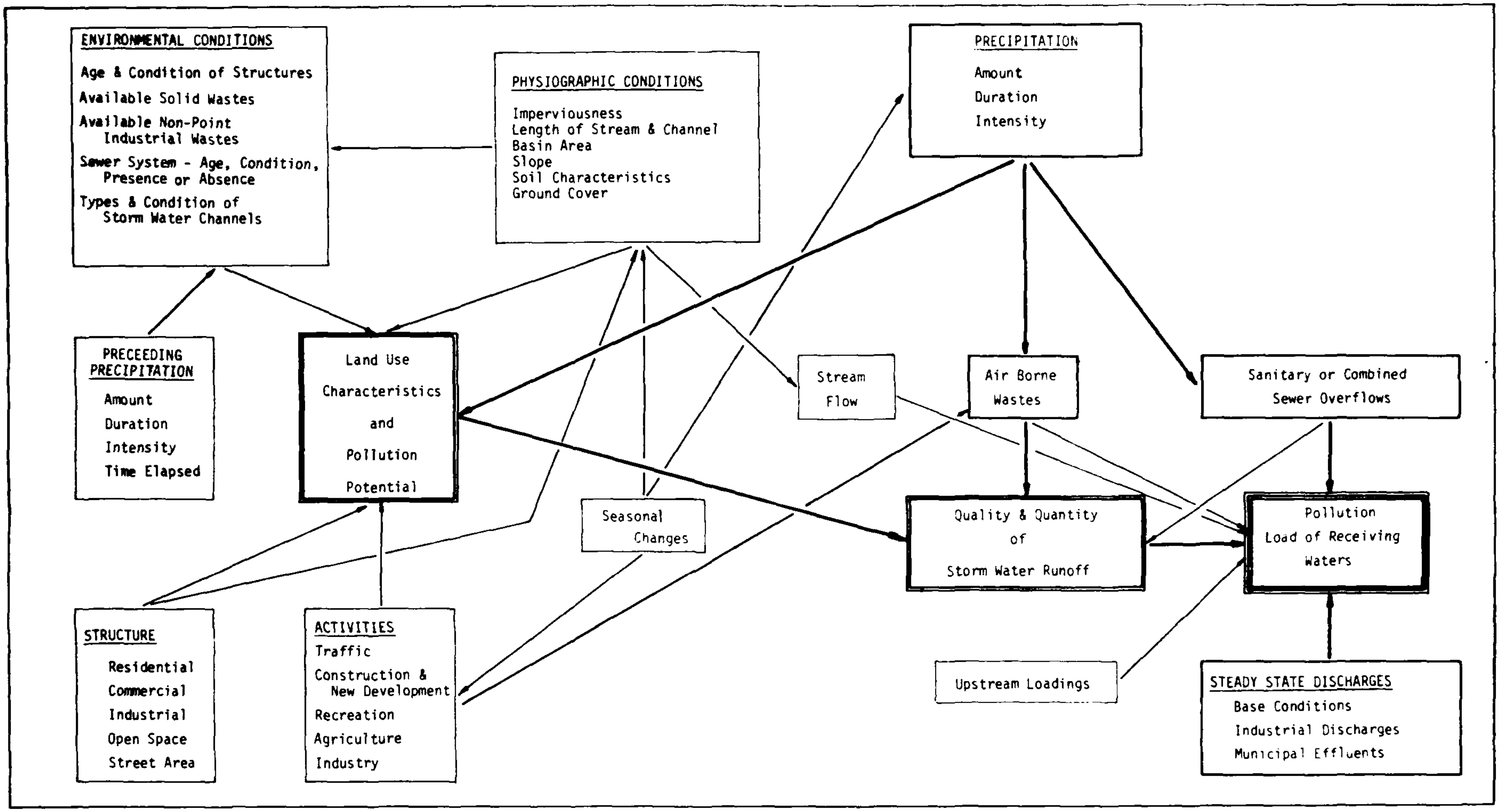



FIGURE IV-1: VARIABLES INFLUENCING THE QUALITY & FLOW OF STORMWATER RUNOFF AND RECEIVING WATERS

b. Storm Water Quality.

There are no previous studies dealing with runoff and stormwater quality in the Study Area or southern Arkansas, therefore, to provide a frame of reference for the present study of storm and baseflow water quality analyses, selected studies outside of the Study Area are reviewed. The review is organized into four basic modes: 1) possible sources of runoff pollutants, 2) selected studies of runoff water quality, 3) selected studies in receiving stream water quality, and 4) a review of the correlations between stormwater quality and land use.

(1) Possible Sources of Runoff Pollutants.

A survey of 149 American cities by the American Public Works Association (1969) identified six major sources of runoff pollutants: 1) spillage from over-loaded trucks, 2) yard refuse (leaves, lawn clippings), 3) improperly used trash receptacles, 4) debris from construction and demolition, 5) roadside dumping, and 6) poor public cooperation. These six factors were listed as problems by at least 81 per cent of the cities responding to the questionnaire. These sources are also considered to be active pollutant contributors in the Study Area. They can increase one or more of the following and, therefore, alter the water quality in the Study Area: suspended and dissolved solids, oxygen consuming substances, nutrients and bacteria.

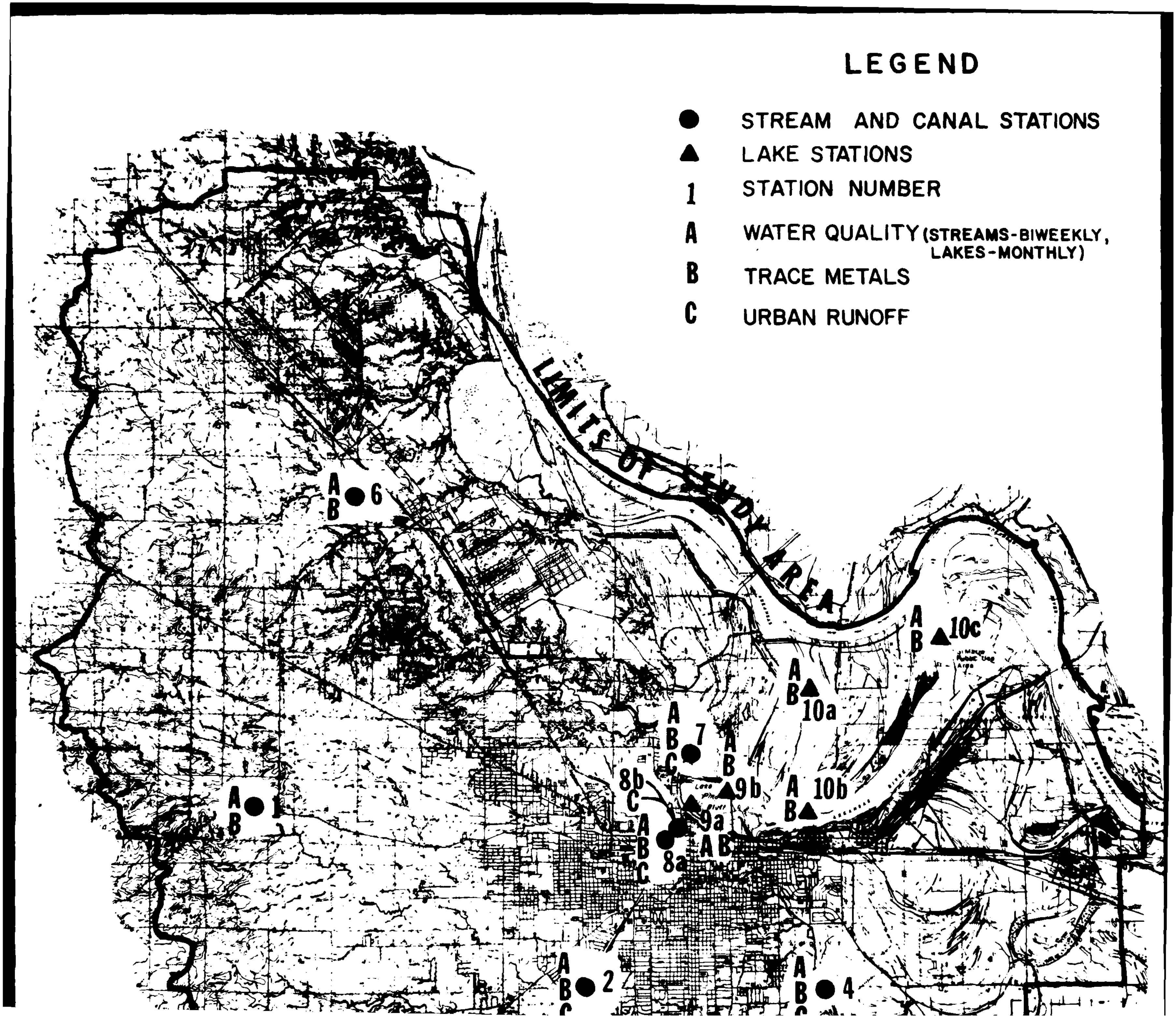
Dustfall and suspended particulates are often a source of stormwater pollution. An analysis of these parameters in the Study Area, however, indicated that they currently present no problem to the area's receiving waters (see also Section IV.B.4). The same is also true for heavy metals (see also Section IV.B.4). Pesticides and herbicides are also often a source of chemical runoff pollutants. They also present no problem to the receiving waters of the Study Area (see also Section IV. C).

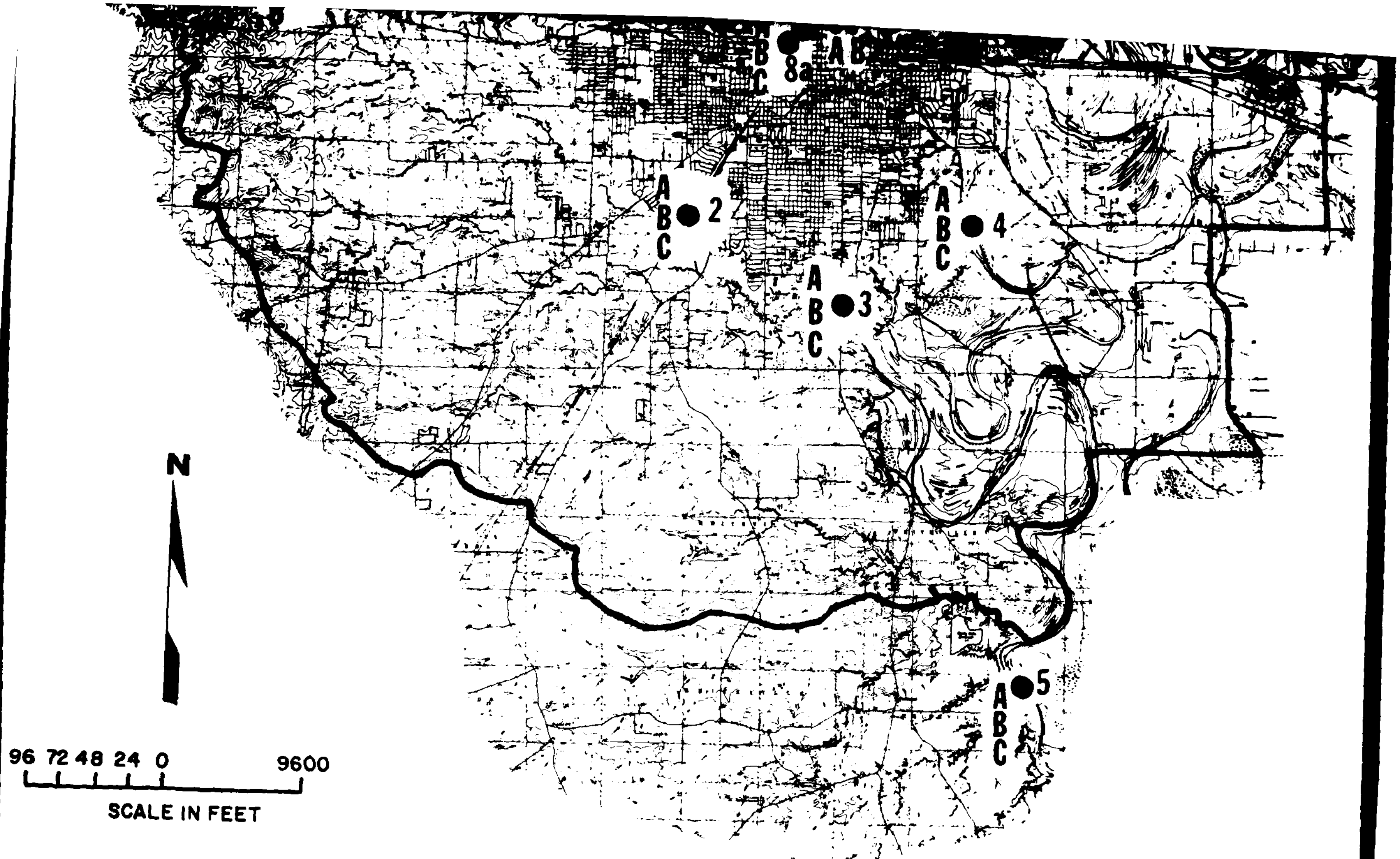
(2) Selected Studies of Runoff Water Quality.

To compare the results of the Pine Bluff stormwater sampling program (Figure IV-2), four cities of previous studies were selected: Bucyrus, Ohio; Cincinnati, Ohio; Tulsa, Oklahoma; Durham, North Carolina. The cities were selected because their studies focused on only stormwaters and not receiving streams and had a comparable data base. In Table IV-1 the ranges and means of the three urban stations of Pine Bluff are used for comparison (Interceptor Canal, Station 2; Outlet Canal, Station 4; Brumps Bayou, Station 8). The data of the remaining stations were omitted as they drained large rural areas and primarily monitored the impact of stormwater runoff to receiving streams. The Pine Bluff data are introduced here only for comparison.

(3) Selected Studies of Runoff Water Quality in Receiving Streams.

Only the study of Fayetteville, Arkansas (Livingston, 1973) was used to compare the Pine Bluff urban stormwater data to stormwater analysis after entry into a receiving stream. It is a much more appropriate comparison in that all of the Pine Bluff storm stations were located in drainage canals


LEGEND
● STREAM AND CANAL STATIONS
▲ LAKE STATIONS
1 STATION NUMBER
A WATER QUALITY (STREAMS-BIWEEKLY, LAKES-MONTHLY)
B TRACE METALS
C URBAN RUNOFF
LIMITS OF STUDY AREA
A B 1
A B 2
A B 4
A B 6
A B C 7
A B C 8a
8b C
9a A B
A B 9b
A B 10a
A B 10b
A B 10c




WATER QUALITY SAMPLING STATIONS
OF THE PINE BLUFF STUDY AREA

FIG. IV-2

TABLE IV-1

STORMWATER ANALYSES FOR SELECTED CITIES AND PINE BLUFF STATIONS (SEE FIGURE IV-2)

| | BUCYRUS[a] | CINCINNATI[b] | TULSA[c] | DURHAM[d] | PINE BLUFF STATION 2 | PINE BLUFF STATION 4 | PINE BLUFF STATION 8 |
|---|---|---|---|---|---|---|---|
| BOD (mg/l) | | | | | | | |
| Mean | 120 | 19 | 12 | 14.5 | 6.7[e] | 11[e] | 8.7[e] |
| Range | 11-560 | 2-84 | 1-39 | 2.2-232 | 1.6-12 | 3.3-41 | 4.7-19 |
| COD (mg/l) | | | | | | | |
| Mean | 413 | 99 | 86 | 179 | 33 | 36 | 39 |
| Range | 64-476 | 20-610 | 12-405 | 40-600 | 4.0-57 | 18-70 | 12-88 |
| Suspended Solids (mg/l) | | | | | | | |
| Mean | 470 | 210 | 367 | - | 836 | 359 | 224 |
| Range | 20-2,440 | - | 89-2,052[f] | - | 4-3,552 | 11-2,788 | 0-737 |
| Total Solids (mg/l) | | | | | | | |
| Mean | 1,142 | - | 545 | 2,730 | 994 | 496 | 326 |
| Range | 150-3,755 | - | 199-2,242 | 274-13,900 | 98-3,776 | 109-3,117 | 133-791 |
| Fecal Coliform Bacteria (per 100 ml) | | | | | | | |
| Mean | $1.6 \times 10^6$ | $.01 \times 10^6$ | $.002 \times 10^6$ | $.3 \times 10^6$ | $.05 \times 10^6$ | $.08 \times 10^6$ | $.09 \times 10^6$ |
| Range | - | - | - | $.003 \times 10^6$-$1.9 \times 10^6$ | 110-$.25 \times 10^6$ | 0-$.44 \times 10^6$ | 90-$.33 \times 10^6$ |

SOURCES: a) Burgess & Niple, LTD, 1969; b) Weibel et al., 1964; c) Economic Systems Corp., 1970; d) Bryan, 1970;
e) Arithmetic Means f) Range of Means

containing baseflow. Moreover, the two studies could be compared over a much wider range of parameters (Table IV-2). Fayetteville was significantly higher in COD and nitrates, whereas, in total phosphorus and the coliform counts the Pine Bluff Study Area stations 4 and 8a had significantly higher concentrations. In all other parameters, the two communities were comparable.

(4) Correlation of Stormwater Quality and Drainage Area Characteristics.

Recently, a number of studies have attempted to statistically correlate specific land use and meteorological variables with water quality using correlation matrices, factor analysis and multiple linear regressions. Most of these have concentrated on the urban environment and storm loading (Bryan, 1970; Economic Systems Corporation, 1970; Mische, 1971), but baseflow conditions (Coughlin and Hammer, 1973) and rural runoff (Weidner et al., 1969) have also been explored. Also, it is important to note that because of the complexities involved, useful correlations are to date scarce. Not only has there been a lack of sufficient data to adequately deal with the requisite variables, but it has been difficult to completely isolate the effects of stormwaters from overflows, steady-state discharges, upstream loadings and air-borne wastes (Figure IV-1). Some of the results of these correlations are presented below. These findings are also applicable to the Study Area.

(a) Tulsa, Oklahoma.

A study in Tulsa (Economic Systems Corporation, 1970) revealed that total coliform bacteria are best correlated with the general environmental conditions of the area (housing, vacant lots, general sanitary conditions, residential density and the length of unpaved streets). The solids correlated with open space and the percentage of paved streets which indicates development and imperviousness. Chemical oxygen demand (COD) correlated with residential density and the length of covered storm sewers. Both solids and COD may be indicators of decay of vegetable and animal matter. A large portion of the pollutants resulted from the washout of materials deposited on impervious surfaces and the erosion of drainage channels caused by high volumes of runoff generated by impervious surfaces.

(b) Tucson, Arizona.

A study in Tucson (Mische, 1971) showed a high correlation between land use (undeveloped land) and suspended solids and turbidity. The correlation coefficients for the bacterial organisms were low. Coefficients for volatile suspended solids and COD concentrations generally did not indicate a strong correlation with any of the land use characteristics.

(c) Philadelphia, Pennsylvania.

In a study conducted by Coughlin and Hammer (1973), large increases in the concentration of a series of inorganic minerals were correlated with the population in unsewered dwellings and with the population in dwelling units whose sewage is disposed of within the watersheds surveyed.

TABLE IV-2

STORMWATER ANALYSIS AT FAYETTEVILLE, ARKANSAS AND PINE BLUFF AT SELECTED URBAN STATIONS (SEE FIGURE IV-2)

| | | PINE BLUFF STUDY AREA | | |
|---|---|---|---|---|
| | FAYETTEVILLE* | STATION 2 | STATION 4 | STATION 8 |
| COD (mg/l) | | | | |
| Mean ** | 88 | 33 | 36 | 39 |
| Range | 32.2-143.5 | 4.0-57 | 18-70 | 12-88 |
| $NH_4$ (mg/lN) | | | | |
| Mean ** | 0.54 | 0.12 | 0.68 | 0.22 |
| Range | 0.31-0.85 | 0.04-0.2 | 0.1-2.6 | 0.04-0.5 |
| $NO_3$ (mg/lN) | | | | |
| Mean ** | 0.36 | 0.01 | 0.02 | 0.01 |
| Range | 0.10-0.62 | 0-0.03 | 0-0.08 | 0-0.02 |
| Total Phosphorous (mg/l) | | | | |
| Mean ** | 0.06 | 0.18 | 0.21 | 0.31 |
| Range | 0.02-0.11 | 0.02-0.58 | 0.03-0.32 | 0.01-1.44 |
| Total Solids (mg/l) | | | | |
| Mean ** | 880 | 994 | 496 | 326 |
| Range | 250-2,460 | 98-3,776 | 109-3,117 | 133-791 |
| Suspended Solids (mg/l) | | | | |
| Mean ** | 403 | 836 | 359 | 224 |
| Range | 4-1,740 | 4-3,552 | 11-2,788 | 0-737 |
| Fecal Coliforms | | | | |
| Mean ** | 48,700 | 48,000 | 75,000 | 89,000 |
| Range | 0-106,000 | 110-250,000 | 0-438,000 | 90-330,000 |

* SOURCE: Livingston, 1973.

** Arithmetic Means.

Although the most significant correlations were with sanitary waste disposal, the overall indication was that urbanization was likely to cause degraded water quality regardless of sewage disposal. The contribution of unsewered dwelling units is inversely related to their distance from the stream channel. Other findings related chemical concentrations to manufacturing employment and soil drainage characteristics.

3. Land Use of the Sampling Area.

To provide a framework for the interpretation of surface water quality, the existing land use of the sampling station drainage areas is presented in Table IV-3. The land use associated with Lake Langhofer (stations 10a, b and c) was not determined as the boundaries of its drainage unit have not been established. Table IV-3 shows that stations 2, 4, 8a, 8b, 9a, and 9b have the highest percentage of urban type development and are collectively referred to as urban stations. Stations 1, 3, 5, 6, and 7, with less than 13 per cent urban type development, are considered rural.

4. Sources of Surface Water Contamination.

The urban and rural areas with their complexities of land use, activities and associated wastes are a dominant force in determining the quality of receiving surface waters. As indicated in Figure IV-1, the urban pollution potential consists of steady-state discharges and complex storm related or non-point discharges.

This section attempts to magnify the urban and rural areas and some of their potential impacts on receiving stream waters. It is in no way definitive, as data from the most fundamental facets of the Pine Bluff urban area such as sanitary wastes, industrial discharges and surface wastes are only beginning to be accumulated. The six most basic pollution problems follow.

a. Sewage Collection and Treatment Facilities.

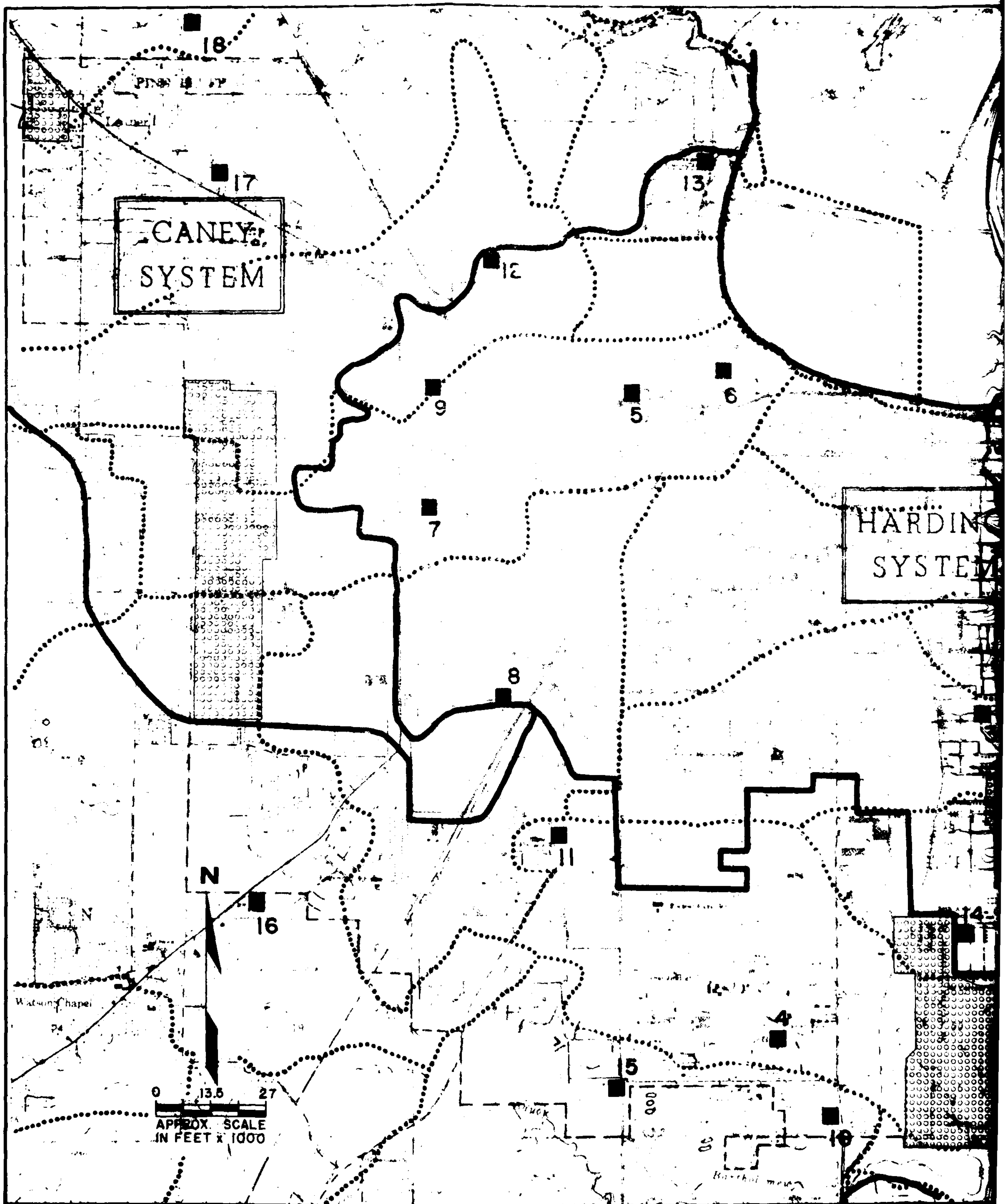
The collection facilities serving Pine Bluff consist of approximately 244 miles of sewer pipe, varying in size from 6 to 42 inches, and 18 pumping stations (Figure IV-3). Along the network, there are approximately 18,000 sewer connections serving an estimated population of 58,000 or about 93 per cent of the City's total population (M. Crist and Associates, 1970).

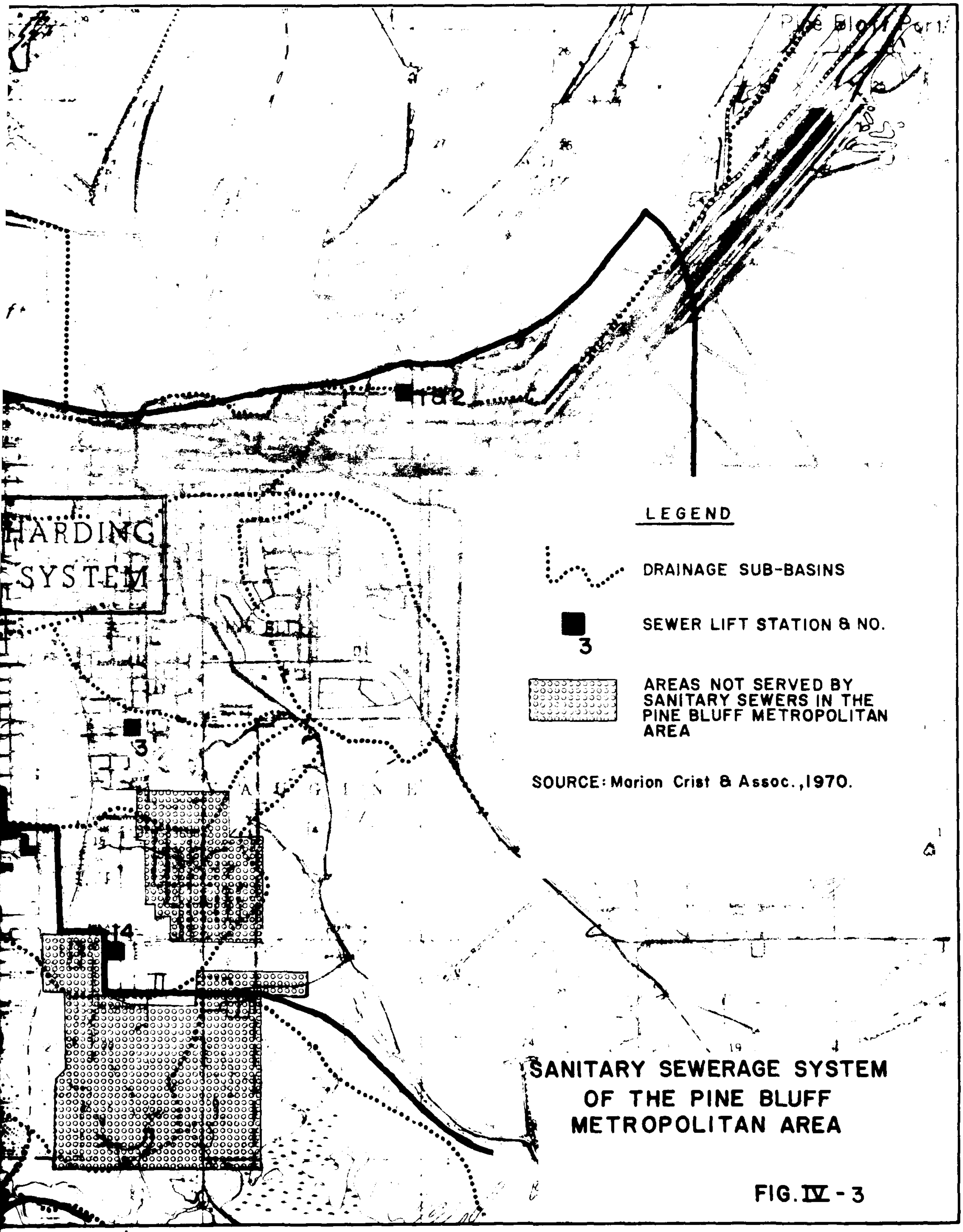
The municipal system is served by two separate sewer systems (Harding and Caney), which divide north to south along approximate natural surface drainage boundaries (Figure IV-3). Sanitary wastes in portions of the City to the south and west of the two systems are pumped either into Caney or Harding for treatment and disposal.

Sewage from the Harding System is collected at the Kansas Street Station and pumped through a force main under Lake Langhofer to the Boyd Point oxidation ponds. The ponds consist of two independent 165-acre cells. The influent, split equally between the cells, was estimated at 3.9 MGD (sic) and represents 79.0 per cent of the sewer connections (Arkansas Department of Pollution Control and Ecology, 1974a). Effluent from the west and east

TABLE IV-3 EXISTING LAND USE OF THE MONITORING STATIONS' DRAINAGE AREAS

| WATER QUALITY AND RUNOFF SAMPLING SYSTEMS | HYDROLOGIC UNITS SAMPLED | TOTAL AREA $mi^2$ | URBAN TYPE DEVELOPMENT | | RURAL & CLEARED | | CROPLAND | | FORESTED LAND | | MAJOR WATER BODIES (+ OXID. PONDS) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | AREA $mi^2$ | PER CENT | AREA $mi^2$ | PER CENT | AREA $mi^2$ | PER CENT | AREA $mi^2$ | PER CENT | AREA $mi^2$ | PER CENT |
| **Upper Caney** Station 6 | Caney | 17.00 | 0.54 | 3.2 | 3.9 | 22.9 | 0 | 0 | 12.54 | 73.8 | 1.01 | 2.6 |
| **Lower Caney** Station 7 | Caney, Caney Fork, Lower Caney I & II, Oakland and Dollarway | 38.40 | 4.66 | 12.1 | 7.82 | 20.4 | 0 | 0 | 25.72 | 67.0 | 0.21 | 0.5 |
| **Brumps** Stations 8a, 8b | Southern, Central & Eastern Regions (Culvert Station) | 1.30 | 1.6 | 88.9 | 0.19 | 10.6 | 0 | 0 | 0.01 | 0.5 | 0 | 0 |
| | Northeastern Region (Confluence Station) | 0.20 | 0.1 | 50.0 | 0.1 | 50.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total (Less Eastern Region) | 2.00 | 1.7 | 85.0 | 0.29 | 14.5 | 0 | 0 | 0.01 | 0.5 | 0 | 0 |
| **Lake Pine Bluff** Stations 9a, 9b | Brumps, & Pine Bluff | 3.4 | 2.2 | 64.7 | 0.36 | 10.6 | 0 | 0 | 0.03 | 0.9 | 0.81 | 23.8 |
| **Princeton Pike** Station 1 | Princeton Pike | 11.00 | 0.10 | 0.9 | 1.84 | 16.7 | 0 | 0 | 9.05 | 82.3 | 0.01 | 0.1 |
| **Interceptor** Station 2 | Interceptor (Excluding Southern Tip) | 2.36 | 1.7 | 72.0 | 0.26 | 11.0 | 0 | 0 | 0.4 | 17.0 | 0 | 0 |
| **Highway 15** Station 3 | Princeton Pike, St. Luke, Flying Duck, Upper Bartholomew I & II, Sulphur Springs, Gravel, Nevins, Lower Nevins, Watson Chapel, Liberty, Southwestern, Interceptor, Middle Bartholomew | 53.1 | 4.62 | 8.7 | 8.72 | 16.4 | 0 | 0 | 39.18 | 74.4 | 0.28 | 0.5 |
| **Outlet** Station 4 | Harding, Town Branch, Belmont, Pitts Drain, Lamont & Outlet (Upper Portion) | 6.99 | 5.4 | 77.3 | 0.35 | 5.0 | 0.55 | 7.9 | 0.69 | 9.8 | 0 | 0 |
| **Pineburgen** Station 5 | All of Bartholomew System | 103.50 | [illegible] | 20.2 | 13.88 | 13.4 | 9.36 | 9.5 | 66.7 | 64.4 | [illegible] | [illegible] |


CANEY SYSTEM
HARDIN SYSTEM
18
17
13
12
9
5
6
7
8
11
16
14
4
15
10
N
0
13.5
27
APPROX. SCALE IN FEET x 1000
Watson Chapel




SANITARY SEWERAGE SYSTEM OF THE PINE BLUFF METROPOLITAN AREA

FIG. IV - 3

cells has been estimated at 1.86 MGD (sic) and 1.26 MGD (sic), respectively (Arkansas Department of Pollution Control and Ecology, 1974a). Analyses of influent and effluent quality are presented in Table IV-4.

Sewage from the Caney System is collected by an outfall line discharging to the Caney oxidation ponds on the southern edge of the Arsenal. The ponds serving approximately 21 per cent of the total Pine Bluff sewer connections consist of a 61.5 acre primary cell and a 7.4 acre finishing cell. Effluent estimated at 1.1 MGD is discharged into Caney Bayou (Arkansas Department of Pollution Control and Ecology, 1974a). Table IV-5 presents the results of influent and effluent analyses.

In addition to the major treatment facilities, the City of Pine Bluff has recently acquired a small oxidation pond (5 acres) located south of Bayou Bartholomew along Hazel Street. Effluent from the pond enters Bayou Bartholomew above Station 3.

The City of Whitehall, seven miles northwest of Pine Bluff has, over the past year, installed a small oxidation pond consisting of a 10.5-acre primary cell and a 4.2-acre finishing cell. Effluent is discharged through a small stream into Caney Bayou. Within the City of Pine Bluff, approximately 4,000 persons are estimated to be served by septic tanks (M. Crist and Associates, 1970). The principle unsewered areas are indicated on Figure IV-3 and are important contributors of sanitary wastes. The combination of poor soil permeability and high ground water levels are not conducive to septic tank efficiency and much of the effluent is poorly treated and discharged into the drainage network by percolation and overland flows.

In most southeastern communities such as Pine Bluff where rainfall is abundant throughout the year, there is movement of storm waters (inflow) and ground water (infiltration) into the collection system. Both inflow and infiltration combine to overload the system and cause raw sewage to be discharged at manholes or by-passed at pumping stations (Crist Engineers, Inc., pers. comm.).

During periods of dry weather and lowered ground water tables, sewage in older lines will enter ground and surface waters as exfiltration. This is particularly pronounced in older portions of the City, but can occur anywhere there is leakage through joints or cracks in the lines.

Throughout the collection network, construction activities near existing lines can accidentally crack or shear laterals or mains causing the discharge of sewage to the surface.

(1) An Inventory of Municipal Sanitary Waste Problems.

Each urban sub-basin is described below as to the source and approximate magnitude of sanitary wastes. Numbers in parentheses indicate pump stations which are located on Figure IV-3.

TABLE IV-4

ANALYTICAL RESULTS OF BOYD POINT OXIDATION POND SAMPLING

| PARAMETER | SOURCE | MEAN CONCENTRATIONS WEST POND (mg/l) | MEAN CONCENTRATIONS EAST POND (mg/l) |
|---|---|---|---|
| pH | Influent | 7.3 | 7.3 |
| | Effluent | 9.4 | 8.7 |
| Alkalinity | Influent | 188 | 188 |
| | Effluent | 117 | 118 |
| Chlorides | Influent | 23 | 23 |
| | Effluent | 28 | 28 |
| $BOD_5$ | Influent | 192 | 192 |
| | Effluent | 31 | 29 |
| COD | Influent | 334 | 334 |
| | Effluent | 107 | 148 |
| Total Solids | Influent | 519 | 519 |
| | Effluent | 344 | 352 |
| Suspended Solids | Influent | 107 | 107 |
| | Effluent | 43 | 78 |
| Dissolved Solids | Influent | 413 | 413 |
| | Effluent | 301 | 273 |
| Settleable Solids | Influent | 4.0 | 4.0 |
| | Effluent | 0.1 | <0.1 |
| Nitrate | Influent | 0.30 | 0.30 |
| | Effluent | 0.45 | 0.53 |
| Total Phosphorus | Influent | 9.5 | 9.5 |
| | Effluent | 4.0 | 5.8 |

SOURCE: Arkansas Department of Pollution Control and Ecology, 1974a.

TABLE IV-5

ANALYTICAL RESULTS OF CANEY OXIDATION PONDS

| PARAMETER | SOURCE | MEAN CONCENTRATIONS PRIMARY CELL (mg/l) | MEAN CONCENTRATIONS FINISHING CELL (mg/l) |
|---|---|---|---|
| pH | Influent | 7.2 | 7.2 |
| | Effluent | 7.2 | 7.5 |
| Alkalinity | Influent | 170 | 159 |
| | Effluent | 159 | 131 |
| Chlorides | Influent | 38 | 36 |
| | Effluent | 36 | 38 |
| $BOD_5$ | Influent | 198 | 30 |
| | Effluent | 30 | 27 |
| COD | Influent | 446 | 177 |
| | Effluent | 177 | 168 |
| Total Solids | Influent | 576 | 376 |
| | Effluent | 376 | 363 |
| Suspended Solids | Influent | 137 | 33 |
| | Effluent | 33 | 33 |
| Dissolved Solids | Influent | 439 | 342 |
| | Effluent | 342 | 330 |
| Settleable Solids | Influent | 7.4 | <.1 |
| | Effluent | <.1 | <.1 |
| Nitrate | Influent | 0.53 | 0.14 |
| | Effluent | 0.14 | 0.30 |
| Total Phosphorus | Influent | 15.8 | 14.5 |
| | Effluent | 14.5 | 14.3 |
| Cadmium | Influent | <.004 | <.004 |
| | Effluent | <.004 | <.003 |
| Chromium | Influent | <.004 | <.004 |
| | Effluent | <.004 | <.004 |
| Copper | Influent | .070 | <.040 |
| | Effluent | <.040 | <.020 |
| Iron (total) | Influent | 0.744 | 0.182 |
| | Effluent | 0.182 | 0.175 |

SOURCE: Arkansas Department of Pollution Control and Ecology, 1974a.

(a) Arkansas River Basin.

1. Caney Bayou System - Inventory.

a. Caney Fork.

The Caney Fork watershed encompasses the northern and western portions of the community of Whitehall and rural residents to the northwest along Highway 65. Septic tank effluents and overflows during storm periods are the major sanitary problems of this watershed. With the full implementation of Whitehall's sanitary facility, many of these discharges will be eliminated.

b. Lower Caney (I & II).

The Lower Caney watersheds include the urban areas of southeastern Whitehall, Henslee Heights and a small portion of Pine Bluff. With the exception of Henslee Heights, most of the urban areas are sewered or will be with the completion of the Whitehall Sanitary treatment program. The bayou in this watershed receives the effluents of both the Caney and Whitehall oxidation ponds. Two pumping stations (13 and 18) are located in the watershed; one on Hutchenson Street serves the Jefferson Park area and the other at Highway 79 and Collegiate Drive serves the University area (Figure IV-3). Field surveys conducted in January, 1975, revealed that for both stations the immediate area is well-drained and without evidence of by-passing (Crist Engineers, Inc., pers. comm.).

c. Dollarway.

The Dollarway watershed includes primarily sewered residential areas without identifiable problems. One pump station (17) is located at the end of Bush Street and, although it is the terminal collector of the Caney Sanitary System, there are no identifiable problems or by-passes associated with it (Crist Engineers, Inc., pers. comm.).

d. Oakland.

The central portion of the Oakland watershed consists of sewered residences with no obvious problems. Two pumping stations (9 and 12) located at Barraque and Bois D'Arc and at North Myrtle, respectively (Figure IV-2), similarly revealed few problems with all manholes in the adjacent area sealed and no raw sewage being discharged to the surface (Crist Engineers, Inc., pers. comm.). However, in the south central regions, south of the expressway, there are poor service lines (Crist Engineers, Inc., pers. comm.).

2. Brumps Bayou System - Inventory.

a. Brumps.

The Brumps sub-basin, containing the heaviest concentration of industry, the largest percentage of unsewered residences, the most pumping stations of any single watershed, and some of the oldest lines

in the sanitary collection system, is beset with numerous sanitary waste problems. The pumping station (5) at Barraque and Spruce (Figure IV-3) which serves both industrial and domestic sanitary wastes discharges through a by-pass manhole and passes raw sewage into adjacent Brumps Bayou. The incoming 12-inch line to the pumping station located at North Ash (6) surcharges into Brumps Bayou during periods of heavy flow and, upstream from the station, the first manhole consistently overflows during storm periods. The pumping station at Peach and Burnett (7), although servicing a problematic area, does not appear to be by-passing (Crist Engineers, Inc., pers. comm.).

b. Lake Pine Bluff.

The drainage surface area of Lake Pine Bluff is small and includes mainly sewered residential areas along its southern and western shores. To date, there are no major problems indicated for the sewered areas.

(b) Ouachita River Basin.

1. The Bartholomew System - Inventory.

a. Gravel.

Although the dominant land use of the Gravel watershed is forest and pasture land, its eastern edge is largely urban-residential. Flow from Watson Chapel and residences to the east to the pumping station located on Highway 79 and Bayou Bartholomew (16) is very heavy and sewage could potentially surcharge upstream manholes near the Bayou Bartholomew bridge. The impact of these waste problems were monitored at stations 3 and 5.

b. Interceptor.

Drained by Interceptor Canal, the watershed is principally a mixture of residential, commercial and industrial developments. With the exception of several industries and scattered residential areas, the drainage area is sewered and serviced by a small capacity pumping station (8) at Howard and Miramar streets (Figure IV-3). From 16th Street north, the area is characterized by poor service lines. The force main from the station discharges into the first manhole east in the center of Howard Street when both pumps run together during heavy flows. This manhole then overflows and floods the street with sewage (Crist Engineers, Inc., pers. comm.). All discharges from Interceptor are collected by Interceptor Canal and were monitored at Station 2. Discharges of sanitary wastes were also monitored at Station 3.

c. Middle Bartholomew.

The seven per cent urban area is confined primarily to two new subdivisions on opposite sides of Bayou Bartholomew. Almost all of the area is served by sewer connections without indications of exfiltration or manhole surcharges. Two pumping stations are located in Middle Bartholomew; one at 46th and Hazel streets (15) and the other near Sheffield

Drive, south of the bayou. Both are small in capacity and are in good repair (Crist Engineers, Inc., pers. comm.). Major discharge of sanitary wastes for the watershed is effluent from the five-acre oxidation pond serving the southern subdivision. The treated effluent is received by Bayou Bartholomew above Highway 15. Discharges of sanitary wastes were monitored at Station 3.

d. Town Branch.

Analogous to Brumps, Town Branch has some of the oldest lines in the City and a heavy concentration of industry; some discharging to septic tanks, others serviced by the municipal collection system. The watershed also includes the Kansas Street pumping station and its standby system which pumps the sewage of the Harding collection system to Boyd Point. Problems within the watershed center around exfiltration from poor joints and cracked lines associated with the age of the system. The most pronounced of these is an old trunk line which runs east and west between Third and Fourth avenues. Moreover, elevated mains crossing drainage canals and channels will occasionally exfiltrate to the surface stream or tributary. Discharges were monitored at Outlet Canal at Station 4.

e. Harding, Belmont and Pitts Drain.

Each of these watersheds is primarily residential with almost all residences connected to the municipal system. Wastes discharge into the surface systems with exfiltration through poor joints and cracked lines. These are most pronounced in the older Harding sub-basin. Manhole surcharges or by-passes have not been reported in these watersheds, although flows are quite heavy to the pumping station at 21st and Indiana (3). Discharges were monitored at Outlet Canal at Station 4.

f. Outlet.

The Outlet watershed is 16 per cent residential-commercial with only scattered industries. With the urban areas restricted to the northern corner, the majority of land is in agricultural use. Although within the urban area dwellings are tied to the sanitary system, there have been reports of exfiltration or discharge resulting from inflow and infiltration. Discharges were monitored at Outlet Canal at Station 4.

g. Lamont.

Lamont is a small watershed, but it includes most of the unsewered residences in the eastern half of the Metropolitan area (Figure IV-3). It also includes a small capacity pump station (14) located at 34th and Missouri streets. There are no visible problems associated with the pumping station. Discharges were monitored at Outlet Canal at Station 4.

h. Eden Park and Imbeau.

These two sub-basins discharging to Bayou Bartholomew by way of Eden Park Drain and Bayou Imbeau are collectively 29 per cent urban. The majority of the urban area is connected to the sanitary collection system. Consistent overflows of sewage occur at the manhole between 36th

and 37th streets and flow to the 42nd and Elm streets pumping station (4). Sewage back-up is heavy and on at least one occasion was within four to six inches of the top of the wet well (Crist Engineers, Inc., pers. comm.). The pumping station at 29th and Fir streets (11) has normal flows and no obstructions or problems were visible during the 1975 survey. Both Eden Park and Imbeau contributions were monitored with the entire Bartholomew System at Station 5.

(2) An Inventory of Septic Tank Discharge Problems.

(a) Arkansas River Basin.

In the Lower Caney watersheds both domestic and industrial septic tank discharges contribute partially treated sanitary wastes to Caney Bayou.

In the Dollarway watershed a small development along the western edge is unsewered and presumably discharges raw (during heavy rains) into a tributary of Caney Bayou.

In the Oakland watershed numerous domestic and industrial septic tanks overflow and discharge into Caney Bayou through the surface drainage network (Crist Engineers, Inc., pers. comm.).

The western portions (Taft to Franklin avenues) of the Brumps sub-basin are unsewered and septic tanks in concert with rainfall, high ground water levels and impervious soil frequently overflow or discharge only marginally treated sewage. Eastward of Taft Avenue to the railroad, surveys report poor and problematic service lines and numerous instances of industrial and domestic septic tank overflow (Crist Engineers, Inc., pers. comm.).

(b) Ouachita River Basin.

In the Gravel watershed, the residences from 12th Street to 19th Street and along Shannon Road are unsewered and discharge ultimately into Bayou Bartholomew. The Watson Chapel area and new developments south of Fawcett Road are largely sewered and do not have identifiable problems. There are, however, several residences and one of two industries which utilize septic tanks.

In the area north of 16th Street in the Interceptor watershed an industrial septic tank overflows, and the flows in that area are heavy to the pumping station.

Septic tank discharges and occasional overflows constitute the major contribution of sanitary wastes in the Lamont watershed.

In the Eden Park and Imbeau watersheds, there are scattered septic tanks serving both residences and industry.

(3) Analysis of Sewage Collection and Treatment in the Study Area.

The inflow of sanitary wastes affects the concentrations of bacteria, nutrients (phosphorus and nitrogen), organics (BOD and COD) and dissolved oxygen which determine the quality of the receiving waters which play a major role in determining the structure of aquatic communities; the potential use of surface waters for recreation, industry and water supply; and the overall biological productivity of the area.

Although the intrusion of sanitary wastes was evident at all Study Area stations, its effects were most pronounced in the water quality and aquatic biology of stations 4, 7, 8, and 9a (see also Sections IV.B.6. and VI.B.).

b. The Stormwater Collection System.

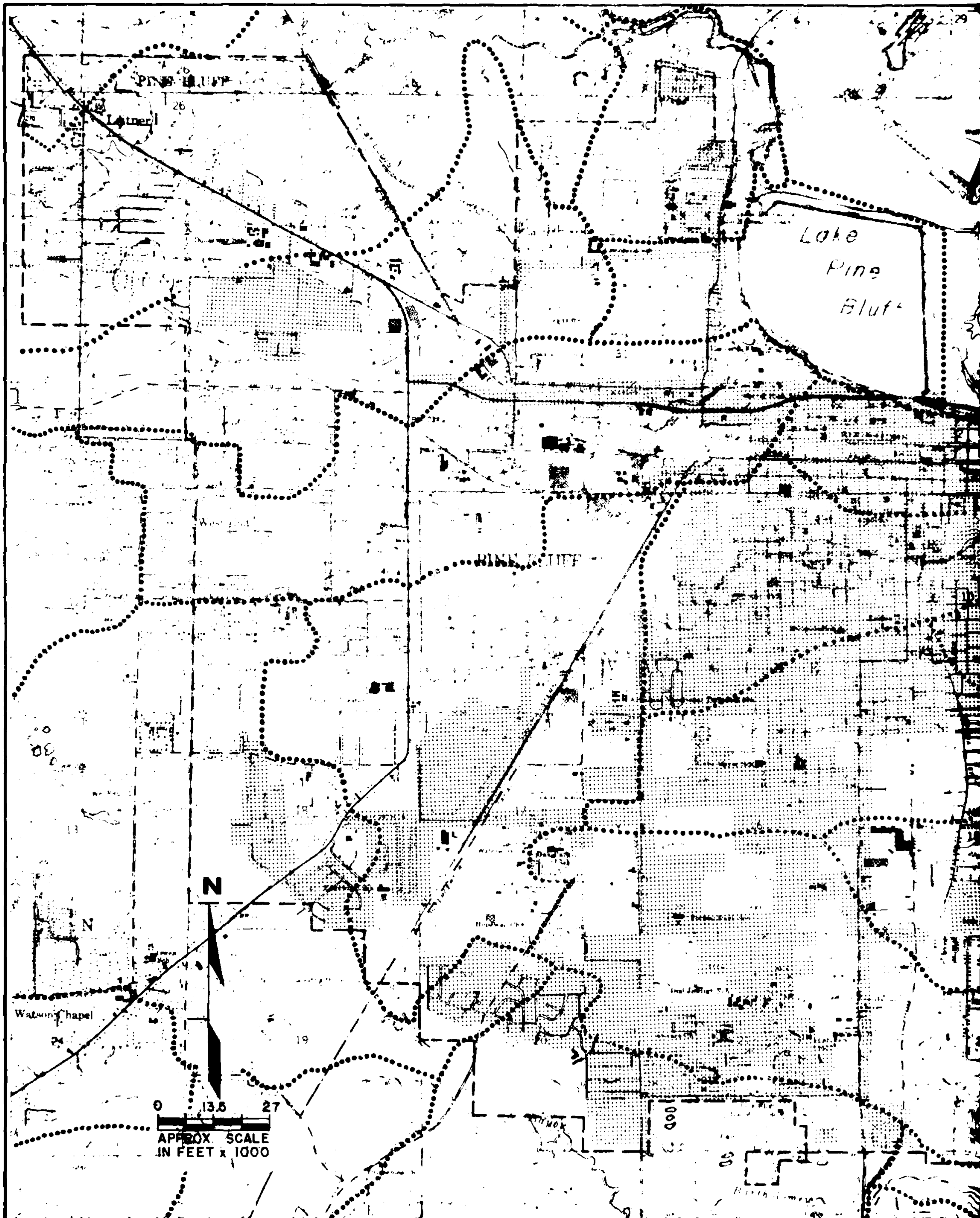
(1) Introduction and Discussion.

As of 1970, 93 square miles of the Pine Bluff Metropolitan Area were serviced by concrete storm sewers and associated curbed and guttered streets. These mileages represent approximately 36 per cent service; with additions over the past few years, the service is now estimated to be at 50 per cent (Figure IV-4). The lines of the storm sewer system vary in size from 18 to 36 inches and discharge into nearby drainage channels. The remainder of the metropolitan area is served by open drainage channels which parallel the streets and empty into the various drainage canals and tributaries. In most areas, these channels have been deepened and widened over the years to relieve flooding, but in many peripheral areas of the City, only irregular natural channels serve to conduct stormwaters.

There are numerous obstructions to flow throughout both types of storm sewers. With low slopes, much of the entrained wastes of stormwaters are deposited on the floors of the channels or sewer lines. Within the open system, vegetation and non-degradable solids (i.e., bottles, cars), are notable obstructions, and because of its accessibility to roads and walkways, the open system also receives many non-storm related wastes. The enclosed system with its grated storm drains is less cluttered, but still receives an array of accumulated debris.

Both the enclosed and the open drainage sewer systems can be major contributors to the loading of stormwaters. Often this takes the form of an initial shock load with the rapid rise in the concentration of water quality parameters at the onset of the storm. The shock loads were most apparent for COD, nutrients and bacteria at all urban stations and are derived from the retention and partial degradation of stormwater and wastes. Typically, it is only after a series of rain events that they are ultimately moved into the receiving stream.

Within the open system, the problems of uncontrolled stormwater retention ("pretreatment") are pronounced. Moreover, the open channels and their exposed wastes are unsightly and, during the summer months, entrapped and eutrophic waters become anaerobic and release unpleasant odors. This has become quite pronounced in Town Branch, where stormwaters will be trapped


Lake
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PINE BLUFF
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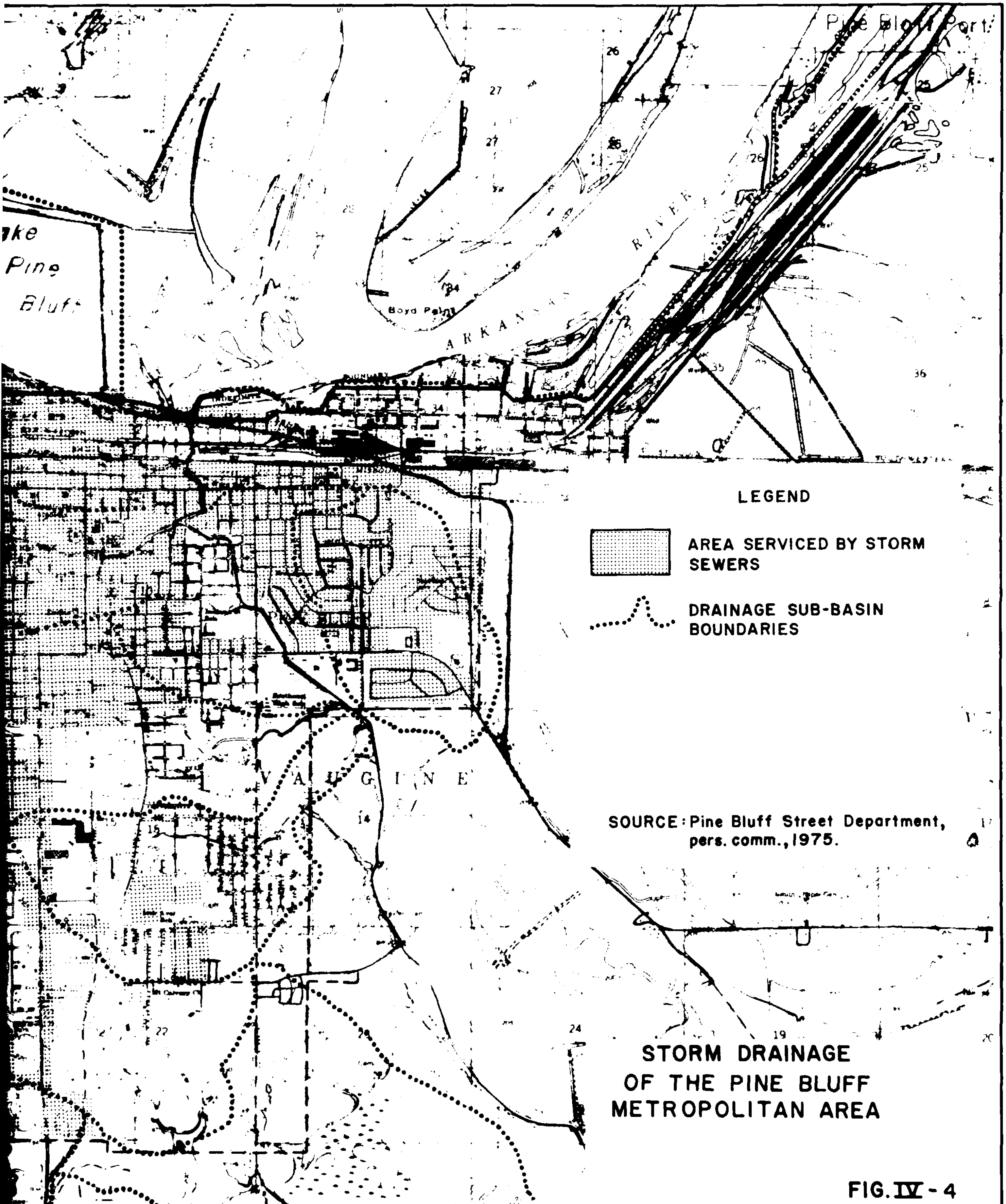



STORM DRAINAGE OF THE PINE BLUFF METROPOLITAN AREA

FIG. IV - 4

between the flood gate to the north of Second Street and the actual Arkansas-Ouachita drainage divide to the south. In addition, the open channels, although typically vegetated, are subject to erosion and the introduction of additional silt and sediment to the stream systems.

The enclosed storm sewer lines obviate many of the problems associated with the open channel, but as an impervious surface, it will increase the volume and rate of runoff. This will be reflected by the receiving stream in both the timing and magnitude of peak flow as indicated by the hydrographs of stations 2 and 4 (Figures A-4, A-5 appended).

(2) <u>Field Observations</u>.

Although no systematic survey of open storm drains was undertaken, a number of observations were made in various parts of the metropolitan area with respect to visible pollution characteristics. In the western residential areas (Blake Street and West), drains were observed to be cluttered with vegetation and residential debris (cans, bottles, paper products, etc.). Toward the industrial areas of Fifth and Sixth streets and along Ohio Street, the open storm drains contained black oily residues. During almost all seasons throughout the City, standing water was conspicuous for several days following storm events, especially in the eastern sections of Pine Bluff.

(3) <u>Estimates of COD and BOD Loading</u>.

To estimate the potential organic contribution of the drainage network, the following assumptions were made: the daily accumulated BOD load was estimated at one pound per mile of closed drain (comparable to streets) and two pounds per mile of open drain; the COD loads were estimated from urban water quality data (Appendix C) to be four times that of the BOD or four and eight pounds per day per mile of closed and open drains, respectively; each storm was considered to transport a minimum of seven days accumulation to the receiving stream (seven and 28 pounds of BOD and COD, respectively, per mile of closed drain and 14 and 56 pounds of BOD and COD, respectively, per mile of open drain).

Using these assumptions and the area and open-closed drainage composition of each sampled watershed, the contribution of BOD and COD by storm drains was estimated (Table IV-6, see also Table IV-19).

c. <u>Industrial Discharges</u>.

(1) <u>Inventory</u>.

The Study Area has approximately 70 businesses which can be classified as industries. The distinction between commercial and industrial business is, however, often arbitrary. In this inventory, we have used the Directory of Arkansas Industries (1972) as a base. Although industrial discharges can, potentially, be one of the major determinants of stream water quality, the quality and quantity of their effluents are of the least known within the Study Area.

## TABLE IV-6

## ESTIMATES OF BOD AND COD LOADING BY RAIN STORM DRAINS

| STATION AND DRAIN COMPOSITION | MILES OF STORM DRAIN | POUNDS PER MONITORED STORM EVENT | |
|---|---|---|---|
| | | BOD | COD |
| Station 2 (50% closed; 50% open) | 13 | 137 | 548 |
| Station 4 (70% closed; 30% open) | 38 | 346 | 1,384 |
| Station 8 (20% closed; 80% open) | 14 | 176 | 704 |
| Station 7 (10% closed; 90% open) | 14 | 186 | 744 |
| Unmonitored (65% closed; 35% open) | 14 | 132 | 528 |

Table C-68 (appended) lists each of the industries of the Study Area, their Standard Industrial Classification (SIC) number, their products and their location as to sub-basin. Their tie to the municipal sewer system is also indicated as is their treatment facilities, if any. Figure IV-5 locates the industries of the metropolitan area by SIC number.

The vast majority of the industries of Pine Bluff are connected to the municipal sewer collection system; for most of these the discharge is sanitary wastes, but for others the discharge is a combination of both industrial waters (process water, wash water, etc.) and sanitary wastes. Table IV-7 lists some of the industries which are connected to the municipal system and quantitative estimates of their daily discharges. It is not possible at this time to subdivide these estimates into industrial and sanitary fractions, but it is apparent from the data that for a number of industries much of their total discharge is wash or process wastes. Only two industries (Hudson Pulp and Paper Corporation and Valmac Industries) are known to have pretreatment of wastes (Table C-68, appended) prior to discharge to the sanitary system.

A number of industries discharge sanitary wastes into the municipal system, but employ septic tanks for their industrial effluents; others utilize septic tanks for all waste products (Table C-68, appended).

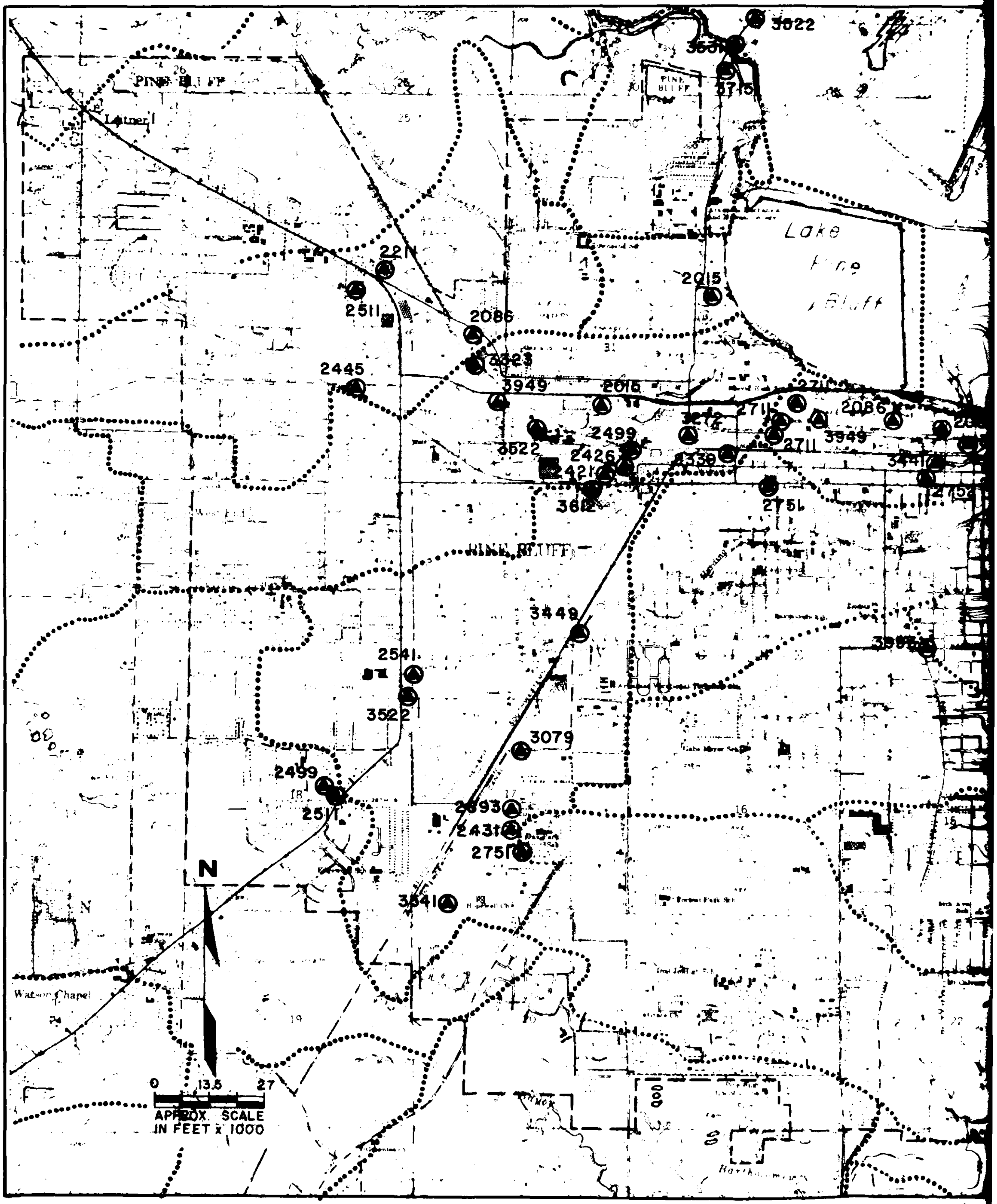
Whenever discharges are made to Arkansas surface waters, either as a direct discharge or following pretreatment, and whether continuous or intermittant, a discharge permit must be acquired through the Arkansas Department of Pollution Control and Ecology. Before issuance of the permit, there must be approval of discharge quality and the treatment of design facilities. Four large industries have had to secure discharge permits as a part of the National Pollution Discharge Elimination System under the Environmental Protection Agency (EPA). This requires effluent limitations designed for that particular industry by the EPA and the submittal of discharge monitoring reports indicating compliance or non-compliance with those Federal standards.

Although the State and Federal permit program is not complete, it has encouraged the monitoring of many industrial effluents and the establishment of treatment facilities. The programs of the Water Pollution Control Survey of the Arkansas River Basin (Arkansas Department of Pollution Control and Ecology, 1974a), the Waste-Load Allocation Studies for the Arkansas and Ouachita River Basins (Bryant and Reed, 1974; Reed et al., 1974) and the ongoing Discharge Monitoring Reports of the National Pollution Discharge Elimination System (NPDES) have provided a closer characterization of the industrial discharges for the Study Area.

The majority of industries discharging to surface waters are within the Arkansas River Basin and are concentrated in the Arkansas System and the Brumps and Lower Caney (I and II) sub-basins (see Appendix C for "Major Industries Discharging to Surface Waters" and Table C-68.

(2) Analysis of Industrial Discharges.

The impact of industrial discharges on the receiving streams will vary with flow, season and base conditions. Moreover, it is impossible to separate sanitary and industrial sources at the monitoring stations. For


3022
Lake
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Bluff
PINE BLUFF
Latner
2211
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2445
3949
2015
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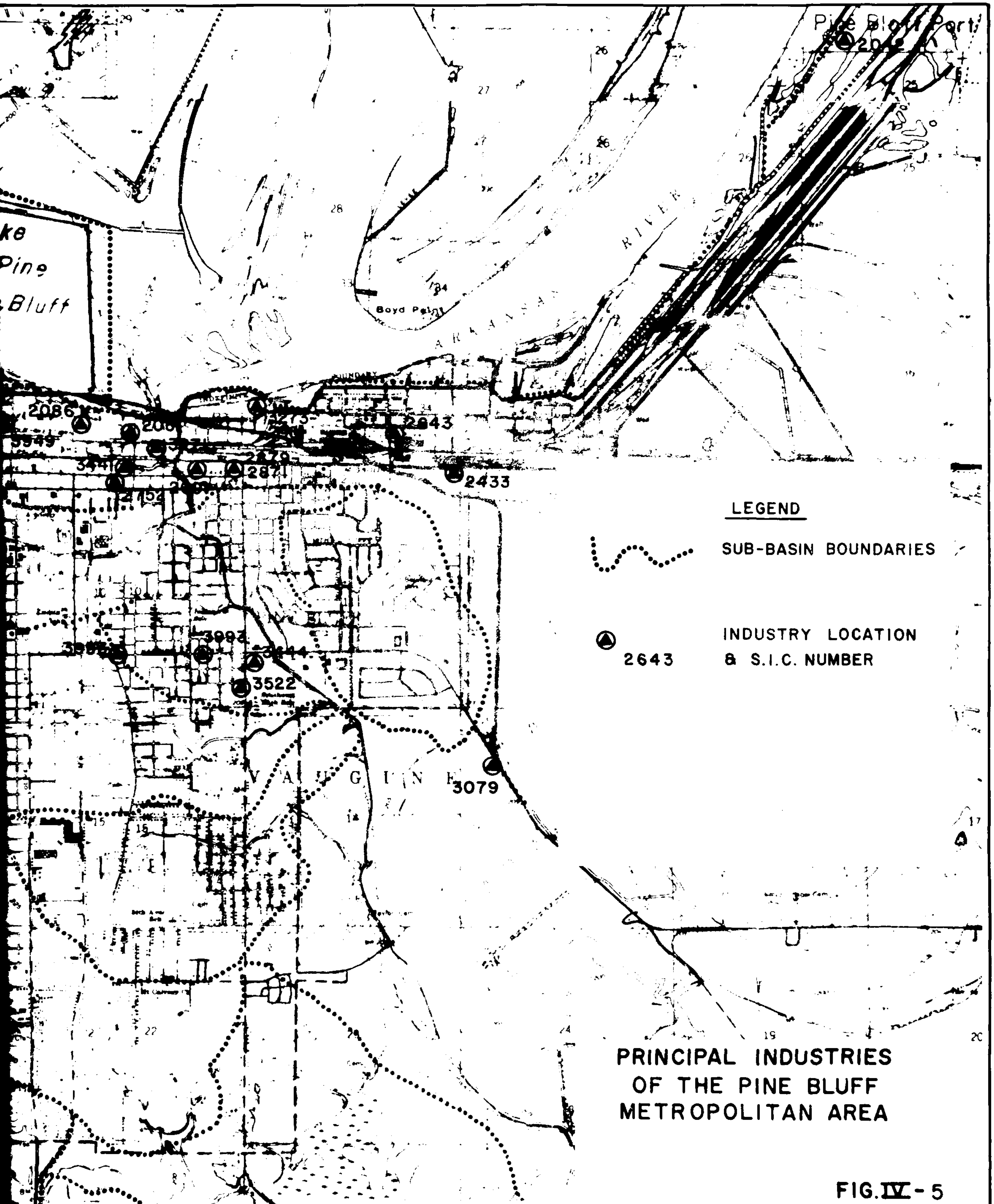


PRINCIPAL INDUSTRIES OF THE PINE BLUFF METROPOLITAN AREA

FIG. IV - 5

TABLE IV-7

INDUSTRIES THAT DISCHARGE TO THE SANITARY SEWERS AND ESTIMATES OF FLOW

| INDUSTRY | SANITARY SYSTEM | GALLONS PER DAY |
|---|---|---|
| Arkansas Oak Flooring Co. | Harding | 35,000 |
| Arkola Sand & Gravel | Harding | 11,590 |
| Ben Pearson Archery | Harding | 57,855 |
| The Borden Company | Caney | 404 |
| Brown Manufacturing Company | Caney | 10,000 |
| Central Transformer Corporation | Harding | 20,000 |
| Clark Printing | Harding | 400 |
| Coca Cola Bottling Company | Harding | 58,700 |
| Coleman Dairy of Arkansas, Inc. | Harding | 160 |
| Cook Industries | Harding | 5,850 |
| St. Louis-Southwestern Railway Co. | Harding | 28,000 |
| CPW Printing Ink, Company | Caney | 400 |
| Dr. Pepper Bottling Company | Harding | 1,400 |
| Federal Compress Plant | Harding | 1,600 |
| Holsom Baking Company | Harding | 6,400 |
| Hudson Pulp & Paper | Harding | 52,471 |
| Illinois Tool Works | Caney | 46,000 |
| Pine Bluff Sand and Gravel | Harding | 1,000 |
| Quality Bakery | Harding | 320 |
| Joeseph E. Seagram & Son | Harding | 1,800 |
| Standard Building Materials Co. | Harding | 120 |
| Standard Brakeshoe Foundry | Harding | 5,600 |
| Standard Ice Company | Harding | 100 |
| Valmac Industries, Inc. (Poultry Wastes) | Harding | 706,000 |
| R.G. Varner Steel Products | Harding | 3,848 |
| Wafford Manufacturing Company | Caney | 1,380 |

SOURCE: Crist Engineers, Inc., pers. comm.

Caney and Brumps bayous, the impact at the current level of effluent analysis and understanding will be in increases in BOD, COD and suspended solids (Section IV.B.6). For Brumps, these increases appear more severe; however, the discharges of the Arsenal and Dixie Wood Preserving Company into Caney are not known and make comparisons uncertain. Other influences are unknown.

d. Miscellaneous Identifiable Wastes.

The urban area and its concentration of human activities generates large quantities of miscellaneous wastes daily which then become available to stormwater runoff. These include a wide spectrum of materials including dustfall, street and surface debris and pesticides and herbicides for lawns and gardens.

For the 17 square miles of urban development within the Study Area, the quantities of these wastes and their composition will vary with land use and industrial and commercial areas typically generating more wastes than residential areas, but this varies with season, physiography and environmental conditions (Figure IV-1).

(1) Atmospheric Wastes.

See Section V.B.2. and 3. and Table V-6 for a treatment of atmospheric wastes and their influences on water quality.

(2) Street Refuse.

Street refuse is the array of materials found on the street, sidewalk, or along the curb and gutter. The sources of street refuse vary from community to community, from season to season, and from area to area within the same community.

Metropolitan Pine Bluff has an estimated 250 miles of paved streets of which approximately 100 miles have curbs and gutters. The curbed and guttered streets are maintained biweekly by two street sweeping machines which remove an estimated 500 cubic yards of refuse over the week period (50 cubic yards per day per machine). Using these street sweeping estimates, the metropolitan area generates five cubic yards per street mile per 14 days or 0.36 cubic yards per mile per day. For the total paved streets, these would be an accumulation of 90 cubic yards of street refuse per day.

With an estimate of 555 pounds per cubic yard, approximately 200 pounds of refuse is accumulated daily per street mile in the Pine Bluff Metropolitan Area. Assuming five pounds of BOD per 1,000 pounds of refuse, which is comparable to other cities, the daily potential storm load would equal one pound BOD per mile or 250 pounds for the paved street network. Assuming an average accumulation period of seven days (days between storms), the potential BOD load per storm from street refuse would be 1,500 pounds of BOD.

At each of the four urban sampling stations, the approximate distribution of the BOD load during a storm event would be as follows: Outlet Canal (4) - 500 pounds; Interceptor (2) - 250 pounds; Brumps (8) - 250 pounds; Lower Caney (7) - 250 pounds; Unmonitored - 250 pounds.

These estimates are based on the following assumptions: uniform BOD loading per mile of paved street; seven days of accumulation; complete flushing by the storm. Although the values are useful for comparative purposes, the BOD of street refuse will vary from area to area and with the low slopes and many obstructions to flow, a storm will seldom bring about total flushing (see also Table IV-6).

(3) Urban Chemicals.

Some of the Study Area's non-point runoff pollution occurs as a result of the use of chemicals to solve other environmental problems; the application of salts for the removal of snow and ice, and the application of pesticides and herbicides in the management of lawns and gardens (see Section IV.C.).

In the Pine Bluff Study Area, with its mild winters and small amounts of snowfall, salt applications are minor and restricted to the major streets and highways and the major commercial areas. Applications are seldom more than two or three times a winter.

A quantitative estimate of yearly usage was made through a survey of retail and wholesale sales and contracts with both the city street and state highway departments. The results indicate that over an average winter, 46 tons of salt (mostly sodium chloride) are used on the streets. Users in the Study Area include: private individuals and businesses - 5 tons; Pine Bluff Street Department - 1 ton; Arkansas Highway Department - 40 tons.

Potentially, the salt is available to runoff waters of either snowmelt or rainfall and is capable of inducing changes in both terrestrial and aquatic systems. Elevated chloride levels, however, have not been recorded at any of the sampling stations, nor have there been appreciable elevations in specific conductivity during winter sampling. Accumulation of these salts over a long period due to evaporation and perhaps to increased salt available to runoff waters will reduce the water quality of receiving waters. The reduced quality will decrease the diversity of the aquatic community and limit the use of the waters by wildlife and man.

(4) Other Non-Quantifiable Sources.

Within the Study Area, or within any urban area, there are a number of sources of wastes which are difficult to detect or quantify. Two dumps are currently operated within the Study Area: one on North Myrtle in the Oakland sub-basin, the other off Highway 54 in Sandy. Both, in addition to burning refuse [it should be noted here that according to the Arkansas Department of Pollution Control and Ecology (1973b) no burning is allowed in the area], operate as sanitary landfills. Each has the potential for the leaching of wastes or waste degradation products to nearby tributaries.

Five car washes in the metropolitan area are recognized as minor, but important dischargers of wastes (detergent, dust and dirt, oil and grease) to receiving streams. The washing of any surface, whether deliberate or by rainfall, will contribute to the total waste load. Also important among these surfaces are gas station aprons, heavy construction equipment and storage yards and industrial areas.

e. <u>Sedimentation and Effects on the Study Area</u>.

Sediment is probably the most significant of the pollutants from agriculture, silviculture and construction and is revealed in tests for turbidity and suspended solids, nutrients and total coliform bacteria. Excessive sediment makes water unfit for municipal and industrial uses, interferes with navigation, destroys esthetic values and injures aquatic life. As a nutrient carrier, it promotes algal growth and hastens the eutrophication of surface waters.

Silt and sediment is destructive to aquatic habitats. Light penetration is reduced, with an immediate effect upon primary production and a delayed effect upon the total biomass of the system. Turbid waters tend to warm up more slowly, delaying fish reproduction and insect emergence. Very heavy siltation will smother eggs or may prevent normal embryo development. Reduced visibility may affect predatory response resulting in imbalanced aquatic populations.

Table IV-8 demonstrates the erosion rates from such land uses as forest, grassland, mines, cropland and construction areas. Erosion rates in construction sites can be as much as 2,000 times those in well-managed forest areas. On a nationwide basis, cropland is the major source of sediment, contributing two billion tons per year or about 50 per cent of the annual sediment delivered to streams and lakes (U.S. Environmental Protection Agency, 1973d).

Well-stocked, well-managed forest land can absorb intense rainfall with little or no resultant runoff due to good tree cover and a forest floor well covered with leaves, decaying twigs and understory vegetation. Forest areas can be made susceptible to erosion by fire, disease and harvesting practices such as clearcutting. Grassland erosion rates exceed those in forest areas by a factor of 10 (Table IV-8). Erosion rates on grassland depend largely upon management practices, i.e., whether overgrazing and the resultant loss of ground cover is controlled.

A number of sediment prediction equations have been formulated, based on quantitative estimates of erosion, transport and yield of silt and sediment (U.S. Environmental Protection Agency, 1973d). One of the most widely used equations for predicting erosion is the Universal Soil Loss Equation (Wischmeier and Smith, 1965). This equation, A=RKLSCP, where:

A= Computed average annual soil loss per unit area

R= Rainfall factor (number of erosion index units in a normal year's rain)

K= Soil erodibility factor

L= Slope length factor

S= Slope gradient factor

TABLE IV-8

REPRESENTATIVE RATES OF EROSION FROM VARIOUS LAND USES

| LAND USE | METRIC TONS/SQ. KM./YEAR | TONS/SQ. MI./YEAR | RELATION TO FOREST = 1 |
|---|---|---|---|
| Forest | 8.5 | 24 | 1 |
| Grassland | 85 | 240 | 10 |
| Cropland | 1,700 | 4,800 | 200 |
| Harvested Forest | 4,250 | 12,000 | 500 |
| Construction | 17,000 | 48,000 | 2,000 |

SOURCE: U.S. Environmental Protection Agency, 1973d.

C= Cropping management factor

P= Erosion control practice factor

takes into account the influence of the total rainfall energy for a specific area rather than the rainfall amount. This equation was used for the Pine Bluff Study Area soil loss computations.

(1) Silt and Sediment Yields: Inventory.

Each sub-basin's theoretical total yearly erosion rate was determined using the Universal Soil Loss Equation. The total erosion rate reflects the sum of rates for all urban-type development, cleared lands, agricultural croplands and forested lands. Total theoretical erosion for all Study Area sub-basins, systems and basins are presented in Table IV-9.

A number of assumptions to the computed sedimentation rates must be noted: 1) a constant factor for vegetative cover was used for all urban areas; construction at specific points within the urban area was not considered, 2) cleared lands within urban areas were considered to have higher erosion rates than those in rural areas, 3) small cropland plots throughout the Study Area were not identified, 4) erosion rates for grasslands were used in forested areas where clearcutting activities have occurred; field reconnaisance verified use of these rates, and 5) stream bank erosion, a serious problem along such waterways as Interceptor Canal, was not considered.

Total sedimentation from construction activities in forested, hilly areas may exceed computed rates for some sub-basins. For example, approximately 10 acres of soil are exposed near the U.S. Army Arsenal - Pine Bluff oxidation pond in the Lower Caney I sub-basin and total sediment yield could exceed 600 tons per year. This total is nearly four times greater than the sedimentation computed for 2,758 acres of forestland in that sub-basin. Highway construction activities in Caney Fork and Upper Bartholomew I sub-basins may expose over 36 acres of soil per mile of construction activity; in one year over 3,100 tons of silt could be transported to nearby waterways. This sedimentation total greatly exceeds total yearly theoretical erosion for both sub-basins (Table IV-9). Present subdivision construction in the Middle Bartholomew sub-basin has exposed approximately 50 acres of soil in one area; even with some revegetation occurring, this area could yield over 600 tons per year of sediment to Bayou Bartholomew. This rate is similar to the total theoretical sedimentation for the entire Middle Bartholomew sub-basin (Table IV-9). High erosion rates in construction areas are temporary, however, and as revegetation occurs, these rates greatly diminish.

(a) Agricultural Sedimentation.

Agricultural cropland activities contribute the majority of sediment to waterways in the Pine Bluff area; the total Study Area cropland (18,176 acres), consisting primarily of cotton and soybeans, contributes 4.05 tons of sediment per acre per year to nearby canals, streams, swamps and backwater areas. However, as discussed in sections IV.B. and VI.B., much of the sediment load is released in areas such as Bayou Imbeau and other wetland

TABLE IV-9

SILTATION RATES BY LAND USE AND SUB-BASIN
(TONS PER WATERSHED PER YEAR)

| SUB-BASIN | LAND USE | | | | TOTALS | |
|---|---|---|---|---|---|---|
| | URBAN TYPE | CLEARED | CROPLAND | FOREST | TONS/YEAR | TONS/ACRE/YEAR |
| Caney | 429 | 1,343 | - | 332 | 2,104 | 0.19 |
| Caney Fork | 963 | 842 | - | 374 | 2,179 | 0.44 |
| Lower Caney I | 1,494 | 692 | - | 163 | 2,349 | 0.52 |
| Lower Caney II | 216 | 88 | - | 5 | 309 | 0.60 |
| Pine Bluff | 131 | 7 | - | <1 | 138 | 0.74 |
| Oakland | 555 | 231 | - | 24 | 810 | 0.55 |
| Dollarway | 556 | 244 | - | 82 | 882 | 0.42 |
| Caney System (Sub-Total) | 4,344 | 3,447 | - | 980 | 8,771 | 0.35 |
| Brumps | 872 | 102 | - | 1 | 975 | 0.66 |
| Arkansas System | 2,525 | 959 | 13,708 | 250 | 17,442 | 0.68 |
| Arkansas Basin (Total) | 7,741 | 4,508 | 13,708 | 1,231 | | |
| Princeton Pike | 86 | 690 | - | 261 | 1,037 | 0.15 |
| St. Luke | - | 163 | - | 113 | 276 | 0.13 |
| Flying Duck | 26 | 244 | - | 97 | 367 | 0.14 |
| Upper Bartholomew I | 118 | 364 | - | 109 | 591 | 0.22 |
| Upper Bartholomew II | 129 | 171 | - | 25 | 325 | 0.32 |
| Gravel | 798 | 95 | - | 95 | 988 | 0.27 |
| Interceptor | 621 | 83 | - | 28 | 732 | 0.46 |
| Sulphur Springs | 19 | 61 | - | 63 | 143 | 0.10 |
| Nevins | 83 | 272 | - | 56 | 411 | 0.17 |
| Watson Chapel | 169 | 146 | - | 33 | 348 | 0.31 |
| Southwestern | 13 | 51 | - | 54 | 118 | 0.07 |
| Liberty | 144 | 165 | - | 109 | 418 | 0.15 |
| Lower Nevins | 145 | 101 | - | 19 | 265 | 0.42 |
| Middle Bartholomew | 264 | 306 | - | 38 | 608 | 0.20 |
| Edin Park | 669 | 73 | - | 5 | 747 | 0.53 |
| Imbeau | 36 | 27 | 7,815 | 19 | 7,897 | 3.27 |
| Town Branch | 264 | 40 | - | - | 304 | 0.44 |
| Harding | 335 | 10 | - | - | 345 | 0.45 |
| Pitts | 358 | 13 | 119 | 2 | 492 | 0.51 |
| Lamont | 209 | 12 | 128 | 4 | 353 | 0.55 |
| Belmont | 170 | 21 | 662 | - | 853 | 1.67 |
| Outlet | 176 | 6 | 8,706 | 8 | 8,896 | 2.90 |
| Lower Bartholomew | 104 | - | 7,971 | 80 | 8,155 | 2.72 |
| Bartholomew at Pinebergen | 20 | - | 5,084 | 12 | 5,116 | 2.37 |
| Boggy | - | 161 | - | 80 | 241 | 0.08 |
| Lower Boggy | 116 | 335 | - | 92 | 543 | 0.11 |
| Sandy | 120 | 351 | - | 174 | 645 | 0.09 |
| Lower Sandy | 37 | 194 | - | 17 | 248 | 0.29 |
| Bartholomew System (Sub-Total) | 5,229 | 4,155 | 30,485 | 1,593 | 41,462 | 0.63 |
| Deep Bayou System | 360 | 151 | 29,514 | 22 | 30,047 | 2.32 |
| Ouachita Basin (Total) | 5,589 | 4,306 | 59,999 | 1,615 | 71,509 | 0.90 |
| TOTAL STUDY AREA | 13,330 | 8,814 | 73,707 | 2,846 | 98,697 | 0.72 |

SOURCE: Data computed from Wischmeier and Smith, 1965 and U.S. Army Corps of Engineers, Vicksburg District, pers. comm.

areas and does not contribute directly to the open streams. The sediment that does enter the primary waterways contributes adsorbed and chemically bonded nitrates, phosphates, pesticides and heavy metals to the stream or canal systems (see sections IV.B.6. and IV.C.).

(b) Sedimentation from Urban-Type Lands.

Urban-type lands yield about 13,380 tons of sediment per year to all Study Area waterways, with an average per acre yield of 0.73 tons for the total 18,240 acres. Sources of urban sediment are erosion from lawns and vacant lots, channel and ditch erosion, and dustfall and construction activities. As noted, new urban residential developments can yield very high local sediment loads for short periods of time. In most areas, this subsides with time; however, Interceptor Canal has significant stream bank erosion during any given storm event. An estimated total of 125 tons of sediment was carried past the 34th Street bridge on Interceptor Canal during one four-hour storm period. If 20 four-hour events occurred yearly, then the 2,500 tons of silt eroded from the banks would exceed the yearly rate of 731 tons (Table IV-9) for the entire Interceptor Canal sub-basin by a factor of 3.4. Bayou Bartholomew is the recipient of all Interceptor Canal sedimentation (Plate IV-1). Due to steepness of slopes along Interceptor Canal, stabilization of the banks is unlikely to occur.

(c) Sedimentation from Cleared (Non-Crop) Lands.

The 18,925 total urban and agricultural cleared land acreage yields about 8,814 tons of sediment per year (Table IV-9) to nearby waterbodies. The per-acre rate value of 0.47 tons in cleared lands is less than the urban erosion rate (0.73) and is much less than the 4.05 agricultural cropland value. Vegetation in the form of lawns, pastures, grassland and brush serves as a strong deterrent to erosion. Overgrazed pastures may yield considerably higher silt loads to adjacent water bodies; however, overgrazing was noted only in scattered areas during field reconnaissance and does not appear to be a problem.

(d) Silvicultural Sedimentation.

About 75,085 acres or 54.6 per cent of the total Study Area is forested in hardwood, pine-hardwood or pine stands. The calculated yearly sedimentation load of 2,846 tons divided by total forested acreage yields 0.04 tons of sediment per acre per year. This erosion value is about one-tenth of the yearly 0.47 ton per acre per year value for cleared lands. Forested lands clearly demonstrate the fewest sedimentation problems. Heavily forested sub-basins such as Caney, Caney Fork, Princeton Pike, St. Luke, Flying Duck, Upper Bartholomew I, Gravel, Sulphur Springs, Southwestern, Liberty, Boggy, Lower Boggy and Sandy, consequently, have the lowest tons per acre Study Area erosion rates (Table IV-9). Runoff analysis at Station 1 (Section IV.B.6.) indicates the effectiveness of forested lands in preventing erosion.

(2) Silt and Sediment Yields: Analysis.

Construction in urban and rural areas and agriculture are clearly the largest contributors of silt to waterways. Both activities demonstrate

Plate IV-1 Confluence of Interceptor Canal and Bayou Bartholomew: a source of sedimentation within the Study Area

similar physical effects regarding abrasive and smothering properties upon biological systems and man-made structures; additionally, cropland sediment carries with it adsorbed and hydrogen-bonded nutrients and pesticides.

(a) Arkansas River.

Construction of the lock-and-dam system on the Arkansas River below Tulsa has probably served to reduce turbidities. However, dissolved salts in the Arkansas River are high and reduced turbidity levels were of minimal beneficial value to industrial use. However, esthetic and recreational use of the river was enhanced by the change of conditions.

(b) Bayou Bartholomew.

Point-source discharges of sediment into Bayou Bartholomew, such as those from Interceptor Canal during runoff periods, serve to smother intolerant aquatic organisms such as mayflies in the confluence area. Most game fishes (except green sunfish) tend to avoid such areas due to silt abrasion upon respiratory structures, smothering of aquatic organisms and nests, hindering of predatory-response and thermal inhibition upon insect emergence and spawning. Significantly, only green sunfish and mosquitofish were noted in Interceptor Canal. Biological diversity at Station 2 was extremely low (Section VI.B.), due to proliferation of the sludgeworm *Limnodrilus*.

Effects of construction activities and sediment discharges from Interceptor Canal are reflected in the total solids and suspended solids of Station 3. Mean annual values for both are significantly higher than those of either the upstream or downstream stations (1 and 5, respectively).

Non-point sediment discharges provide the bulk of silt to Bayou Bartholomew; these discharges emanate mostly from cotton and soybean fields in the Study Area. A significant proportion of silt enters Bayou Imbeau before being carried into Bayou Bartholomew or Outlet Canal (see sections IV.B. and VI.B). The fishery in Bayou Imbeau is probably close to non-existent due to this runoff. Potentially, water from this meander could be used for irrigation.

The sediment that does enter Bayou Bartholomew probably exhibits similar effects upon aquatic life as does that of the Interceptor Canal-Bayou Bartholomew confluence, especially in the area east of Station 3, where bayous Imbeau and Bartholomew hydrologically connect. Downstream effects of sedimentation appear to be minimal from a water quality standpoint (Section III.B.) at Station 5. However, suppressed benthic diversity values at Station 5 (Section VI.B.) indicate some contamination to bottom organisms; siltation may be an important factor here.

(c) Caney Bayou.

Theoretical soil loss computations indicate few siltation problems in this system, with the exception of construction activities and the previously discussed Arsenal oxidation pond problem. The most limiting factors to esthetic and recreational use appear to emanate from introduction of nutrients into the bayou (sections IV.B. and VI.B.).

(d) Lake Pine Bluff.

Contributions of sediment to Lake Pine Bluff by Brumps Bayou and smaller drainages appear to limit benthic invertebrate diversity at Station 9a (Section VI.B.). However, litter and domestic sewage pollution are more important in the degeneration of esthetic and recreational uses of this area than is silt.

Levee repair on Lake Pine Bluff may increase seasonal turbidities; however, effects of this sedimentation are undetermined. Long-term effects of this activity are probably minimal to aquatic organisms in areas away from the levees.

(e) Overall Study Area.

1. Irrigation.

As the Quaternary aquifer provides the majority of irrigation water to the Study Area, sediment in surface water currently is not a limiting factor in irrigation. Irrigation return flows, however, carry sediment, nutrients, minerals and pesticides to receiving waterbodies.

2. Consumption.

Study Area stream water, in order to be fit for consumptive purposes, would have to undergo expensive treatment. Removal of total solids and total dissolved solids will only partially purify the water; high fecal coliform bacteria counts throughout water systems in the Study Area preclude consumptive use without chlorination.

3. Industrial.

No known industrial use exists for surface water in the Study Area; siltation occurring in surface waters is inconsequential to this use.

4. Stock Watering.

Sediment may suppress palatibility of stock pond water or of waterways or may contain excessive levels of nitrates and pesticides. As in fish farming, control of sediment in livestock water supplies is a necessity.

f. Fertilizer Usage and Impacts from Agricultural and Urban Sources.

(1) Fertilizer Usage in Agricultural Areas.

(a) Estimated Yearly Applications and Losses to Waterways.

In 1974, about 9,780 acres in the Study Area were planted with cotton and 6,520 acres were planted with soybeans. In one application, 3,453,752 pounds (1,727 tons) of 60-40-40 fertilizer were applied to cotton

(353 lbs./acre) from February to April and 1,089,174 pounds (544.6 tons) of 0-20-20 fertilizer were applied to soybeans (167 lbs./acre) from March to April (Jefferson County Cooperative Extension Service, pers. comm.).

Runoff from the total 16,306 acres of cotton-soybean lands and 1,570 acres of miscellaneous croplands contributes an average yearly sediment load of 73,707 tons to area waterways (Section IV.B.6.). Using Wadleigh's (1968) estimate that agricultural sediment averages two pounds of nitrogen per ton and 1.6 pounds of phosphorus per ton, then about 147,000 pounds of nitrogen and 118,000 pounds of phosphorus yearly enter waterways adjacent to agricultural croplands. Distribution of nitrogen and phosphorus to watershed systems is as follows: the Arkansas System, 27,930 pounds (14.0 tons) of nitrogen and 22,420 pounds (11.2 rons) of phosphorus; the Bartholomew System, 58,800 pounds (29.4 tons) of nitrogen and 47,200 pounds (23.6 tons) of phosphorus; the Deep Bayou System, 60,270 pounds (30.1 tons) of nitrogen and 48,380 pounds (24.2 tons) of phosphorus. The Arkansas System receives far greater contributions of nitrogen and phosphorus from the Caney oxidation ponds than from the agricultural runoff of these nutrients. In the Bartholomew System, notably at Station 5, summer phosphorus concentrations greatly exceed winter concentrations during storm events. This reflects summer crop fertilization. The relationships between nitrogen and phosphorus runoff and observed water quality in the Deep Bayou System are unknown because this system was not monitored.

(b) Consequences of Agricultural Nutrient Transmission.

As most cropland is fertilized from February to April, heavy subsequent rainfalls during these months probably serve to remove the majority of total yearly sediment and nutrients.

Impacts upon water quality, esthetic use and biological diversity are likely to be most significant in Deep Bayou and its canals and tributaries, as this system contains 61.0 per cent of all croplands on only 9.4 per cent of the total Study Area. Water quality of the entire Deep Bayou waterway is likely to be nutrient rich, especially during spring and early summer. Oxygen demands in Deep Bayou waters are probably significantly low to reduce the fishery. With sedimentation included in the impacts upon water quality, esthetics and biological diversity, usage of the entire Deep Bayou Waterway, for anything but drainage, is seriously limited.

Croplands in the Bartholomew System account for about 9.5 per cent of the total land usage; the entire system comprises 48.3 per cent of the total Study Area. Impacts of agricultural fertilization at Station 5 appear to be minimal (Section IV.C.) and muted by domestic waste contributions from the Pine Bluff urban area and dilution waters from the Boggy and Sandy sub-basins. However, as discussed in Section VI.B., depressed benthic invertebrate diversities at Station 5 do indicate environmental degradation of bottom conditions; nutrient enrichment from agricultural runoff contributes to this degradation. The most significant impacts of fertilization upon water quality, esthetic use and biological diversity, probably occur in Bayou Imbeau and other wetland areas adjacent to agricultural lands (see also

sections IV.B.6. and VI.B.). As in Deep Bayou, usage of Bayou Imbeau is limited to a receiving and settling basin for nutrients, silt and pesticides.

The impact of fertilizers being carried off the Arkansas System's 12.6 per cent (6.2 square miles) agricultural croplands is undetermined and probably minimal, as the Arkansas River and Lake Langhofer receive the majority of runoff from these areas. Compared with point-source discharges of the Boyd Point oxidation ponds (Section IV.C.), contributions of nutrients are insignificant locally. However, the additive effects of upstream and downstream agricultural practices probably have a significant effect upon the water quality and ecology of the Arkansas River.

(2) Fertilizer Usage in Urban Areas.

(a) Estimated Yearly Applications and Losses to Waterways.

Several assumptions had to be made in the derivation of yearly urban fertilizer application rates. First, it was estimated that 20 per cent of all 12,210 owner-occupied residences in Pine Bluff applied both 10-10-10 nitrogen-phosphorus-potassium fertilizer and ammonium nitrate to their lawns. Second, average lawn size was estimated to be 10,000 square feet and the recommended fertilization rate for that size lawn was 150 pounds of 10-10-10 and 100 pounds ammonium nitrate (Jefferson County Cooperative Extension Service, pers. comm.). Third, the Universal Soil Loss Equation was implemented for the urban area with an estimate of 0.6 tons of soil lost per square acre of lawn per year. Fourth, an EPA (U.S. Environmental Protection Agency, 1973d) estimate of 10 per cent nitrogen and 25 per cent phosphorus loss to waterways after agricultural applications was modified to 0.7 per cent and 1.8 per cent for both nutrients, respectively. The lower urban estimates are based on the principle that vegetative cover factors in the urban area are greater than ten times those in croplands.

An estimated total of 366,300 pounds (183 tons) of 10-10-10 fertilizer and 244,322 pounds (122 tons) of ammonium nitrate was applied to area lawns. Of these totals, about 13,310 pounds each of nitrogen and phosphorus are active ingredients of 10-10-10 and 81,441 pounds of ammonium nitrate is nitrogen. Of the 10-10-10, an estimated 93 pounds of nitrogen and 240 pounds of phosphorus is lost to local waterways yearly due to urban erosion. Additionally, about 1,331 pounds of nitrogen in 10-10-10 (10 per cent of total applications) was delivered to local waterways by leaching. Of the total 81,441 pounds of nitrogen in ammonium nitrate, about 590 pounds were estimated to have been delivered yearly to waterways by soils and 8,144 pounds were lost to waterways by leaching. Yearly total losses of nitrogen and phosphorus to area waterways are thus estimated to be 10,158 and 240 pounds, respectively. These loads, however, are probably insignificant when compared to loads contributed by the sanitary sewer system.

(b) Consequences of Urban Nutrient Transmission.

If nitrogen and phosphorus losses to waterways were distributed evenly on an annual basis, then effects upon water quality and aquatic ecosystems of those waterways would be minimal. However, most fertilizers are applied in the spring and early summer months, and rainfall amounts are also

heavy during these periods (see Section II.C.). Noxious blue-green algal blooms occasionally observed throughout the urban area in poorly drained ditches could result from the runoff of fertilizers. Delivery to local canals (primarily Outlet Canal) could seasonally elevate nutrient loads with resulting dissolved oxygen demand and reduced biological diversity. Receiving streams such as Bayou Bartholomew would accumulate nutrients in the bottom mud near canal confluence areas. Nutrient enrichment and oxygen demands in such areas would reduce aquatic diversity, increase the growth of algae, duckweeds and alligatorweed and limit the fishery to small sunfishes because their tolerance to low dissolved oxygen is greater than that of larger individuals and because dense aquatic vegetation protects them fron predation.

5. State and Federal Surface Water Quality Criteria.

a. State.

State water quality criteria (applicable to the current project) as amended by the Arkansas Water and Air Pollution Control Act (Ark. Stats., Sec. 82-1904) and in compliance with the requirements of the Federal Water Pollution Control Act amendments of 1972 (Public Law 92-500, 86 Stat. 816, 33 U.S.C. 1151) are promulgated by Regulation No. 2 (Arkansas Department of Pollution Control and Ecology, 1973), as amended, which establishes water quality standards for all surface waters, inter- and intrastate of the State of Arkansas.

(1) Use Classification (Arkansas Department of Pollution Control and Ecology, 1973).

Substantially all waters of the State are presently suitable for recreational uses in and/or on the water and for the preservation and propagation of desirable species of aquatic biota. The use classifications are defined as follows.

(a) Class AA.

Extraordinary recreational and esthetic value. Suitable for primary contact recreation, propagation of desirable species of fish, wildlife and other aquatic life, raw water source for public water supplies, and other compatible uses.

(b) Class A.

Suitable for primary contact recreation, propagation of desirable species of fish, wildlife and other aquatic life, raw water source for public water supplies, and other compatible uses.

(c) Class B.

Suitable for desirable species of fish, wildlife and other aquatic and semi-aquatic life, raw water source for public water supplies, secondary contact recreation and other uses.

(2) Specific Standards (Arkansas Department of Pollution Control and Ecology, 1973).

(a) Temperature.

During any month of the year, heat shall not be added to any stream in excess of the amount that will elevate the temperature of the water more than 5°F, based upon the monthly average of the maximum daily temperatures as measured at mid-depth or 5 feet, whichever is less. In lakes and reservoirs, the temperature shall not be raised more than 3°F above that which existed before the addition of heat of artificial origin, based upon the average of temperatures taken from surface to bottom, or from surface to thermocline, if present. The maximum temperature due to man-made causes shall not exceed 68°F in trout waters, 86°F in smallmouth bass waters, or 90°F in all other waters.

(b) Color.

True color attributable to municipal, industrial, agricultural or other waste discharges shall not be increased in any waters to the extent that it will interfere with present or projected future uses of these waters.

(c) Turbidity.

There shall be no distinctly visible increase in turbidity of receiving waters attributable to municipal, industrial, agricultural, or other waste discharges. Specifically, in no case shall any such waste discharge cause 1) the turbidity of warm water streams to exceed 50 Jackson units, or of trout or smallmouth bass streams to exceed 10 Jackson units; or 2) the turbidity of warm water lakes to exceed 25 Jackson units, or of cold water or oligotrophic lakes to exceed 10 Jackson units.

(d) Solids, Floating Material, and Deposits.

Receiving waters shall have no distinctly visible solids, scum, or foam of a persistent nature, nor shall there be any formation of slime, bottom deposits or sludge banks, attributable to municipal, industrial, agricultural, or other waste discharges.

(e) Oil and Grease.

Oil, grease or petrochemical substances, attributable to municipal, industrial, agricultural or other waste discharges shall not be present in receiving waters to the extent that they produce globules or other residue or any visible color film on the surface, or coat the banks and/or bottoms of the water course or adversely affect any of the associated biota.

(f) pH.

The pH of water in the stream or lake must not fluctuate in excess of 1.0 pH unit, within the range of 6.0 to 9.0, over a period of 24 hours. The pH shall not be below 6.0 or above 9.0 due to wastes discharged to the receiving waters.

(g) Dissolved Oxygen.

The dissolved oxygen in the waters shall not be less than 5 milligrams per liter (mg/l), and in streams this shall be the critical deficit point of the dissolved oxygen profile. The only exception will be when periodic lower values are of natural origin and, therefore, beyond the control of the water user. For trout and smallmouth bass waters, the minimum dissolved oxygen content shall not be less than 6 mg/l. The dissolved oxygen sample in streams shall be taken at mid-depth or 5 feet, whichever is less, and at mid-stream in smaller streams. On the larger rivers the dissolved oxygen shall be determined by the average of concentrations in samples collected at quarter points across the river.

(h) Bacteria.

The Arkansas State Board of Health has the responsibility of approving or disapproving surface waters for public water supply and of approving or disapproving the suitability of specifically delineated outdoor bathing places for body contact recreation, and it has issued rules and regulations pertaining to such uses. This applies to all other waters and all other water uses, and the following criteria shall apply to waters in the Study Area (Class B Waters): the fecal coliform bacteria content shall not exceed a log mean of 1000/100 ml, nor equal or exceed 2000/100 ml in more than 10 per cent of the samples taken in any 30-day period.

(i) Toxic Substances.

Toxic materials attributable to municipal, industrial, agricultural, or other waste discharges, shall not be present in receiving waters in such quantities as to be toxic to human, animal, plant or aquatic life or to interfere with the normal propagation of aquatic life. For any toxicants, concentrations in the receiving waters after mixing shall not exceed 0.01 of the 48-hour Median Tolerance Limit (TLm), unless they can be shown to be nonpersistent and non-cumulative, and to exhibit no synergistic interactions with other waste or stream components. In no case shall concentrations exceed 0.05 of the 48-hour TLm.

(j) Mineral Quality.

Existing mineral quality shall not be altered by municipal, industrial, agricultural or other waste discharges so as to interfere with other beneficial uses. The following limits shall apply to the streams indicated in Table IV-10.

(k) Nutrients.

The naturally occurring nitrogen/phosphorus ratio shall not be significantly altered due to municipal, industrial, agricultural or other waste discharges, nor shall total phosphorus exceed 100 ug/l in streams or 50 ug/l in lakes and reservoirs due to any such discharges.

(l) Heavy Metals and Pesticides.

There are no state criteria for regulating these parameters.

TABLE IV-10

MAXIMUM ALLOWABLE CONCENTRATIONS OF MINERALS IN SELECTED ARKANSAS STREAMS

| Stream | Concentrations (mg/l) Cl | $SO_4$ | TDS |
|---|---|---|---|
| Arkansas River, Mouth to Lock and Dam #7 (Lake Langhofer) | 250 | 100 | 750 |
| Bayou Bartholomew | 30 | 30 | 220 |
| Tributary Streams in the Study Area (Caney Bayou) | 250 | 250 | 500 |

SOURCE: Arkansas Department of Pollution Control and Ecology, 1973.

b. National Criteria.

(1) General Water Quality Criteria.

The above criteria are equal to, or are more stringent than, those applicable to public water supply use as stated in the report of the National Technical Advisory Committee to the Secretary of the Interior on Water Quality Criteria.

(2) Heavy Metals and Pesticides Criteria (U.S. Environmental Protection Agency, 1973b).

The following proposed water quality criteria concerning heavy metals and pesticides defines the acceptable limits of those constituents in receiving waters based on an evaluation of the latest scientific information by the Environmental Protection Agency. The criteria are listed in tables IV-11, IV-12 and IV-13.

6. Results of the Baseflow and Stormwater Quality Sampling Programs.

Methods of the baseflow and stormwater sampling programs and resulting data are presented in Appendix C. Sampling stations are shown on Figure IV-2. Although heavy metals were sampled during storms, the results are discussed in Section IV.C.

a. Rainfall Events and Results of Rainfall Analyses.

(1) Rainfall Events.

Storm events were selected for sampling on the amount of rainfall and the number of dry weather days preceding the storm. Generally, a storm with one inch or more rainfall and preceded by at least seven days of dry weather met the minimum requirements. Table IV-14 synopsizes the six monitored storms.

Storms were sampled prior to rainfall and shortly after initiation. The remaining six to seven samples were taken sequentially during the runoff period with two to four hours separating the samples in the early part of the storm and 12 to 24 hours near the end of the sampling program (see also Appendix C).

(2) Rainfall Analysis.

Table IV-15 presents a summary of the analytical results of the nutrient and metal analysis of the rainfall. Although the concentrations are low, nutrients and metals were detectable. Estimates of the total amounts of nutrients and metals received by the 214.7 square miles of Study Area during a one inch storm are presented in Table IV-16. These estimates are based on the average concentrations of data given in Table IV-15.

b. Overview of Baseflow and Stormwater Quality.

To facilitate interstation comparisons and to provide a more regional perspective, the data of water quality sampling programs are discussed first

TABLE IV-11

PROPOSED RECOMMENDED WATER QUALITY CRITERIA FOR HEAVY METALS

| PARAMETER | USE | | | |
|---|---|---|---|---|
| | IRRIGATION | LIVESTOCK | AQUATIC LIFE | PUBLIC WATER SUPPLY |
| Al | 5.0 | 5.0 | - | - |
| As | 0.10 | 0.2 | - | 0.1 |
| Be | 0.1 | NL | - | - |
| Bo | 0.75 | 5.0 | - | 1.0 |
| Cd | 0.01 | 50.0 | Hard - 0.03<br>Soft - 0.004 | 0.01 |
| Cr | 0.1 | 1.0 | 0.05 | 0.05 |
| Co | 0.05 | 1.0 | 1/10 of 96 hr. $LC_{50}$ | - |
| Cu | 0.2 | 0.5 | 0.03 | 1.0 |
| Fe | 5.0 | NL | - | 0.3 |
| Pb | 5.0 | 0.1 | 0.03 | 0.05 |
| Li | 2.5 | - | - | - |
| Mn | 0.2 | NL | - | 0.05 |
| Mo | 0.01 | NL | - | - |
| Ni | 0.2 | - | 1/50 of 96 hr. $LC_{50}$ | - |
| Se | 0.02 | 0.05 | - | 0.01 |
| Na | NL* | - | - | NL |
| Hg | - | 0.001 | 0.05 | 0.002 |
| Vd | - | 0.1 | - | - |
| Zn | - | 25.0 | 5/1,000 96 hr. $LC_{50}$ | 5.0 |
| Ba | - | - | - | 1.0 |
| Ag | - | - | - | 0.05 |

* No designated limits.

Source: U.S. Environmental Protection Agency, 1973b.

TABLE IV-12
Recommended Maximum Concentrations of Organochlorine Pesticides in Whole (Unfiltered) Water Sampled at Any Time and Any Place

| ORGANOCHLORINE PESTICIDES | PERMISSIBLE MAXIMUM* CONCENTRATION (ug/l) |
|---|---|
| Aldrin | 0.01 |
| DDT | 0.002 |
| TDE | 0.006 |
| Dieldrin | 0.005 |
| Chlordane | 0.04 |
| Endosulfan | 0.003 |
| Endrin | 0.002 |
| Heptachlor | 0.01 |
| Lindane | 0.02 |
| Methoxychlor | 0.005 |
| Toxaphene | 0.01 |

*Concentrations were determined by multiplying the acute toxicity values for the more sensitive species by an application factor of 0.01.

SOURCE: U.S. Environmental Protection Agency, 1973b.

TABLE IV-13
Recommended Maximum Concentrations (ug/l)* of Other Pesticides in Whole (Unfiltered) Water Sampled at Any Time and Any Place

| ORGANOPHOSPHATE INSECTICIDES | | CARBAMATE INSECTICIDES | |
|---|---|---|---|
| Azinphosmethyl | 0.001 | Carbaryl | 0.02 |
| Ciodrin | 0.1 | Zectran | 0.1 |
| Coumaphos | 0.001 | | |
| Diazinon | 0.009 | HERBICIDES, FUNGICIDES, AND DEFOLIANTS | |
| Dichlorvos | 0.001 | Aminotriazole | 300.0 |
| Dioxathion | 0.09 | Dalapon | 110.0 |
| Disulfonton | 0.05 | Dicamba | 0.2 |
| Dursban | 0.001 | Dichlobenil | 37.0 |
| Ethion | 0.02 | Dichlone | 0.7 |
| EPN | 0.06 | Diquat | 0.5 |
| Fenthion | 0.006 | Diuron | 1.6 |
| Malathion | 0.008 | 2-4,D (BEE) | 4.0 |
| Mevinphos | 0.002 | Fenac (Sodium Salt) | 45.0 |
| Naled | 0.004 | Silvex (BEE) | 2.5 |
| Oxydemeton Methyl | 0.4 | Silvex (PGBE) | 2.0 |
| Parathion | 0.001 | Simazine | 10.0 |
| Phosphamidon | 0.03 | | |
| TEPP | 0.3 | BOTANICALS | |
| Trichlorophon | 0.002 | Allethrin | 0.002 |
| | | Pyrethrum | 0.01 |
| | | Rotenone | 10.0 |

*Concentrations were determined by multiplying the acture toxicity values for the more sensitive species by an application factor of 0.01.

SOURCE: U.S. Environmental Protection Agency, 1973b.

## TABLE IV-14
## Rainfall Synopsis of the Six Monitored Storm Events

May 14-15:
Rain began falling heavily at 1920 hrs. 14 May 74, and continued until about 2100 hrs. Some scattered showers persisted in the area until 2300 hrs. 14 May. Heavy rainfall began again about 0645 hrs. 15 May 74 and continued until 0900 hrs. 15 May 74. Monitored at stations 2, 3, 4, 5, 7, and 8a. Average rainfall, 3.2 inches; length of rain period, 6.0 hrs.

July 25-26:
Rain began falling heavily about 2300 hrs. 25 July 74, and continued until 0230 hrs. 26 July 74. A few intermittent showers were noted in area until 0430 hrs. 26 July 74. Monitored at stations 2, 3, 4, 5, 7, and 8a. Average rainfall, 2.1 inches; rain period, 5.5 hours.

December 5-6:
Rain began falling intermittently and lightly from 2100-2300 hrs. 5 December 74. Moderate rainfall then began at 0200 hrs. 6 December 74, becoming intermittent and ending 0500 hrs. 6 December 74. Fog and light drizzle found in area from about 1700-2200 hrs. 6 December 74. Monitored at stations 1, 2, 4, and 5. Average rainfall, 0.5 inches; rain period, 5.0 hours.

January 9-11:
Intermittent rain (3-5 minute bursts) began about 0100 hrs. 10 January 75, becoming much heavier and longer in duration at 0515 hrs. 10 January 75. Very heavy rainfall noted from 0515-0600 hrs. 10 January 75. Rainfall tapered off and ended at 0850 hrs. 10 January 75. Monitored at stations 7, 8a, and 8b. Average rainfall, 2.0 inches; rain period, 3.5 hrs.

February 22-23:
Light rain began falling at 2130 hrs. 22 February 75. Intermittent light rain continued until 0030 hrs. 23 February 75, when rain became moderately heavy in 15-20 minute periods. This type rainfall continued until 0400 hrs. when rainfall intensity lessened and became more infrequent. By 1400 hrs. 23 February 75, rainfall ceased. Light snow was noted 1730 hrs. 23 February 75. Monitored at stations 1, 2, 4, and 5. Average rainfall, 1.0 inches; rain period, 7.0 hrs.

March 8-9:
Light rain began falling at 1830 hrs. 8 March 75. Intermittent light rain continued through 2020 hrs. 8 March 75, when very heavy rainfall was noted for a 30 minute period. This tapered off to a moderate then to a light intensity rainfall within 1 hour. Sporatic light rain was noted through 2300 hrs. 8 March 75, with several periods of freezing rain interspersed within these rainfalls. Rainfall ceased 2300 hrs. 8 March 75. Monitored at stations 7, 8a, and 8b. Average rainfall, 1.0 inches; rain period, 4.5 hours.

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*Average rainfall is based on records from Grider Field, General Waterworks Corporation and the Pine Bluff Arsenal. Rain period includes intermittent showers.

TABLE IV-15
Rain Water Analysis

| PARAMETER | SAMPLE DATES May 14-15 '74 | July 25-26 '74 | December 6-7 '74 | January 10-11 '75 | February 22-23 '75 | March 9-10 '75 | SELECTED MEANS |
|---|---|---|---|---|---|---|---|
| Hardness (mg/1 Ca $CO_3$) | - | 3.1 | - | - | - | - | - |
| Calcium Hardness (mg/1 Ca $CO_3$) | - | 1.2 | 1.5 | 1.2 | - | 2.8 | - |
| Total Phosphorus (mg/1) | - | 0.11 | - | 0.01 | 0.02 | - | 0.05 |
| Nitrate Nitrogen (mg/1) | - | 0.63 | 0.2 | 0.2 | - | - | 0.34 |
| Nitrite Nitrogen (mg/1) | - | 0.00 | - | - | - | - | - |
| Ammonia Nitrogen (mg/1) | - | 0.21 | 0.1 | 0.1 | 0.2 | 0.5 | 0.22 |
| Total Kjeldahl Nitrogen (mg/1) | - | 0.8 | - | - | - | - | - |
| Lead (mg/1) | - | - | 0.1 | 0.1 | - | 0.1 | 0.1 |
| Zinc (mg/1) | - | - | 0.08 | 0.05 | 0.07 | 0.05 | 0.075 |

TABLE IV-16

Estimates of Pounds of Nutrients and Selected Metals
Contributed to the Study Area During a One Inch Rain Storm*

| PARAMETER | POUNDS/ONE INCH STORM |
|---|---|
| Nutrients | |
| Total Phosphorus | 1,600 |
| Nitrate Nitrogen | 10,600 |
| Ammonia Nitrogen | 6,800 |
| Metals | |
| Lead | 3,100 |
| Zinc | 2,300 |

*Based on the average concentrations of data given in Table IV-15.

by parameter. Data unreduced, summarized and graphed are appended (Appendix C). State and National water quality criteria are given in Section IV.B.5.

(1) pH, Alkalinity, and Temperature.

The pH reflects the geology of the area and the photosynthetic and respiratory activity of the contained organisms. There is a direct correlation between pH and the level of free carbon dioxide (acidity) and bicarbonates and carbonates (alkalinity) in an aquatic system.

The pH ranged from 5.7 (Station 3) to 9.3 (Station 10a). With the exceptions of stations 2 and 8a, all stream stations, as indicated by their annual means, were slightly acidic. The exceptions perhaps reflected industrial or municipal discharges such as the daily discharged ground water into Interceptor Canal (Station 2) by the General Waterworks Corporation. Among the stream stations, Station 1, located near the head waters of Bayou Bartholomew, recorded the lowest annual mean (6.2). The lake stations were alkaline with pH ranging from 7.0 to 9.3. Storm events affected pH levels only slightly and if any patterns were present, pH values tended to be lowered with rainfall. All pH changes recorded which were related to storm events were well within Arkansas state standards.

Total alkalinity, a function of the bicarbonate and carbonate content of water, was closely correlated with pH values and ranged from four (Station 1) to 127 mg/l calcium carbonate (Station 9b). Lake stations were more alkaline than stream stations and alkalinity at the stream stations did not change notably during the storm events. (Lake stations were not sampled during storm events).

Water temperature has long been recognized as a critical parameter because of its direct relationship to biological productivity and because of its inverse relationship to the concentrations of dissolved oxygen and free carbon dioxide.

Mid-water column temperatures of the stream stations ranged from 4.5°C to 29.0°C (40.1°F to 84.2°F). Station 1 generally had cooler water temperatures and the lowest annual mean (14.9°C or 58.8°F). Station 2, with much of its flow resulting from ground water from General Waterworks Corporation, had more stable temperatures and the highest annual mean (19.5°C or 67.1°F). Storm events generally lowered temperatures at all sampling stations.

(2) Dissolved Gases.

Dissolved oxygen in surface waters is critical as an indicator of biological potential. Streams consistently low in dissolved oxygen are uninhabitable for many aquatic organisms and the streams will generally reflect a low biological diversity. Organisms vary appreciably in their tolerance to dissolved oxygen concentrations even within a given species, especially from one stage in the life cycle to another. Dissolved oxygen concentrations vary daily, as well as seasonally, with changes in temperature, photosynthetic activity, physical aeration processes and organic load.

Free carbon dioxide, as a by-product of biological respiration, normally varies inversely with the dissolved oxygen and pH. Although formal standards for free carbon dioxide have not been designated, concentrations in excess of 25 mg/l are considered detrimental to aquatic life (Hynes, 1971).

Dissolved oxygen concentrations recorded for the baseline sampling program varied considerably. In general, low values were recorded at all stations from mid-spring to mid-fall, reflecting low flows, higher temperatures and increased oxygen demands. With the exception of Station 2, all stations had numerous periods in exceedance of state standards. These periods were generally confined to the summer months. They occurred in 25 per cent of the samples from Station 1 and 57 per cent of the Station 4 samples. Supersaturation conditions occurred at all stations during the cooler months of January and February, but were particularly pronounced and prolonged in Lake Langhofer (stations 10a, b and c).

Annual means of dissolved oxygen were lowest at stations 4 and 7, each with an annual mean of 3.9 mg/l. These values most likely represent the intrusion of untreated and partially treated unsanitary wastes and industrial discharges, as well as markedly reduced summer flows. The Lake Langhofer stations consistently had the highest seasonal and annual means as a result of good surface mixing by wind action, a well balanced phytoplankton population, and the absence of significant quantities of municipal or industrial discharges. Among the stream stations, Station 2, despite the predominantly urban character of its watershed, had the highest dissolved oxygen readings during all seasons and the least variation among sampling periods. This reflects a combination of variables, including good year round flow, numerous small riffle areas providing the opportunity for physical aeration, and the absence of baseflow pollution. Moreover, much of the flow at Station 2 originates as relatively good quality ground water from the daily backflushing of General Waterworks' wells near the headwater region of Interceptor Canal.

During storm events, dissolved oxygen recordings were dominated by physical aeration and did not reflect the enhanced pollution loads. Dissolved oxygen levels rose with the onset of rainfall and remained relatively constant over the storm sampling period. Post-storm sampling for periods up to five days following a storm event also revealed little decline in dissolved oxygen.

Free carbon dioxide values were generally high, when dissolved oxygen levels were low. Consequently, high free carbon dioxide concentrations were recorded primarily during the summer months and at stations with low dissolved oxygen levels. Lake stations had significantly lower carbon dioxide concentrations than did stream stations.

Although elevated free carbon dioxide levels (above 20 mg/l) occurred sporatically at stations 2 and 7, they did not exceed the toxic limit of 25 mg/l. Free carbon dioxide was not monitored during storm events.

(3) Optical Properties.

Optical properties included true color, turbidity and Secchi transparency (for stations 9a and b; 10a, b and c) and indicate the penetrability of surface waters to light. Although surface waters of the southeastern

states are frequently naturally colored and often turbid, excessive coloration and/or turbidity will reduce the amount of light and, therefore, reduce the productivity of the entire aquatic system and interfere with many physiological and behavioral functions of fishes and bottom organisms.

True color reflects the interaction of a number of complex variables including the presence of organic acids, pH and municipal and industrial discharges. During the baseline sampling program, color ranged from 10 (Station 9a) to 200 PCU (Station 6). Although variations occurred from sampling to sampling, the annual means of the stream stations did not differ significantly from station to station. Similarly, the lake stations revealed only minor differences between annual mean values; however, the annual means of the lake system as a unit were appreciably lower than those of the streams. During storm events color, most notably at the urban stations, increased in response to runoff. Overall, true water color was good throughout the sampling program.

Turbidity in surface waters results from suspended solids such as clay, silt, finely divided organic substances and plankton. Turbid waters have poor light penetration as the suspended particles cause light to scatter and be absorbed rather than transmitted. Although the instrument used to measure turbidity was not sensitive to the concentrations set by the Arkansas State Standards, turbidities throughout the sampling program were generally low (less than 80 JTU) at all sampling stations. During storm events, turbidities correlated well with levels of suspended solids and increased at all stations. Turbidities at Station 2 were higher (maximum 290 JTU) with the erosion of bank material and channel improvements during the latter part of the sampling year.

Secchi transparency, a visual representation of the relative visibility or light penetration, was only determined at the lake stations (stations 9a and b; 10a, b and c). The recorded annual and seasonal means of the stations did not significantly differ from one another and all stations collectively had an annual mean of 16 cm. Only minor variations were recorded from any station throughout the sampling period and these could not be correlated with a season.

(4) Bacterial Levels.

Domestic and animal wastes in surface waters, in addition to creating an increase in nutrients and oxygen demand, are a potential threat to human health. Pathogenic organisms commonly associated with sewage in surface water systems include bacteria which cause typhoid fever, gastrointestinal disorders, diarrheal diseases, nausea, dehydration, and kidney, liver and central nervous system infections, tularemia and cholera (Bott, 1973; Geldreich, 1972). Because specific pathogens are difficult to identify in routine water quality analysis, total and fecal coliform and fecal streptococcus bacteria have become accepted indicators of domestic and animal wastes in water systems. Total coliform bacteria represent a mixture of free-living species and intestinal species and are less useful as an indicator than are fecal coliform and fecal streptococcus bacteria which are restricted to the intestines of warm-blooded animals. To accurately assess potential health hazards and the source of sanitary wastes, it is

important to distinguish human wastes from those of other animals. A ratio of fecal coliform to fecal streptococcus bacteria of greater than 4:1 generally indicates sewage derived primarily from domestic wastes and a ratio of less than 1:1 indicates wastes from warm-blooded animals other than man (Geldreich et al., 1964; Geldreich and Kenner, 1969). Ratios falling between 1:1 and 4:1 are assumed to be of mixed origin.

The bacterial criteria (Section IV.B.5.) cannot be applied to the baseflow stream samples because a minimum of five samples within a 30-day period must be taken before the standards can be applied, but they can be applied to the runoff sampling program which consisted of seven or eight consecutive samples. In general, the ranges and means of fecal coliform and fecal streptococcus bacteria correlated well with known sanitary waste problems. This was especially true for urban runoff water. In the baseflow sampling program, stations 8a, 4, and 9a had the highest annual means of fecal coliform and fecal streptococcus bacteria. No seasonal patterns for bacterial groups were apparent. During runoff sampling, bacterial concentrations increased rapidly within a few hours of rainfall, declined, and then increased again before undergoing a second decline (Appendix C). The pattern was particularly pronounced for the streptococcus bacteria. The first peak can be attributed to a shock load received from waters already entrapped in drainage channels and ditches, coupled to the beginnings of sewage entering through by-passes and manholes. This first wave of bacterial wastes generally occurred before any appreciable discharge and dilution. The second peak, usually of greater magnitude than the first, can be interpreted as the storm's full effect on by-passes and surcharges. Usually, the second peak was coincident with the hydrologic peak, although stations 5 and 8a were exceptions. Stations 8a, 4, and 2 monitoring the city's interior had the highest annual means of both fecal coliform and fecal streptococcus bacteria for all storm events; Station 1, monitoring relatively undeveloped lands, had the lowest. However, with the exception of Station 1 during the storm of December 6-7, all monitored runoff water was in violation of Arkansas water quality criteria. Comparison of average fecal coliform to fecal streptococcus bacteria ratios indicates sanitary wastes of mixed origin at each runoff station (Table IV-17).

In the comparison of storm events, the intense summer storm of July 25-26, produced the highest levels of fecal bacteria at almost all stations. The winter storms of lesser intensity, while yielding higher concentrations of total coliforms, were appreciably lower in yields of both types of fecal bacteria.

The survival of fecal coliform and fecal streptococcus bacteria varies with seasons. Fecal coliforms, although capable of multiplying in nutrient rich waters, will show a 90 per cent reduction in their population in 3.3 days in summer and in about 15 days in winter. Fecal streptococci, not capable of reproducing outside of the intestinal tract, undergo a 90 per cent reduction in 2.7 days in summer and 20.1 days in winter. During autumn, about 13 days are required for a 90 per cent reduction of both fecal bacteria (Von Donsel et al., 1967). These differential survival rates suggest that although summer storms may generate high bacterial levels, their downstream effects will be minimized by short survival. For winter storms, the effects will be reversed.

TABLE IV-17

AVERAGE RATIOS OF FECAL COLIFORM TO FECAL STREPTOCOCCUS BACTERIA

| STATION NO. | NO. OF SAMPLES TAKEN | AVERAGE FC/FS RATIO | INDICATION |
|---|---|---|---|
| 1 | 15 | 1.0:1 | Mixed wastes |
| 2 | 26 | 1.3:1 | Mixed wastes |
| 3 | 8 | 1.9:1 | Mixed wastes |
| 4 | 24 | 2.3:1 | Mixed wastes |
| 5 | 21 | 2.3:1 | Mixed wastes |
| 7 | 14 | 1.7:1 | Mixed wastes |
| 8a | 15 | 1.4:1 | Mixed wastes |
| 8b | 7 | 1.9:1 | Mixed wastes |

TABLE IV-18

THEORETICAL LENGTH OF STREAMREACH IN MILES TRAVERSED BY BACTERIAL POPULATIONS BEFORE A 90% REDUCTION IN POPULATION NUMBERS

| | Summer | | Fall | | Winter | |
|---|---|---|---|---|---|---|
| Stream | Coliforms | Streptococci | Coliform | Streptococci | Coliforms | Streptococci |
| Bayou Bartholomew | 54.1 | 44.2 | 219.3 | 219.3 | 245.5 | 328.9 |
| Caney Bayou* | - | - | - | - | - | - |

* All populations intercepted by Lake Langhofer before 90% reduction.

Although stream velocities vary during and following a storm event, an average velocity of 1.0 feet/second for Bayou Bartholomew and 2.5 feet/second for Caney Bayou (U.S. Army Corps of Engineers, pers. comm.) can be used to estimate the length of stream reach traveled before 90 per cent reduction in bacterial population numbers (Table IV-18).

(5) Organics.

Biochemical oxygen demand (BOD) is the amount of oxygen required by microorganisms in the biochemical oxidation of organic matter. Chemical oxygen demand (COD) is the amount of oxygen equivalent to the amount of organic matter susceptible to oxidation by a strong chemical oxidant. COD values are typically greater than BOD due to the presence of organics resistant to biological activity. Neither BOD nor COD are pollutants *per se* but are indicators of possible oxygen depletion through biological and chemical activity. There are no Arkansas standards regulating their values.

Throughout baseline and storm sampling, BOD and COD values were low to moderate and were not strongly correlated with land use. In the baseline sampling program, annual mean COD values were not significantly different from station to station and annual mean BOD values were only slightly elevated at the urban stations (stations 4, 8a, and 7). Both BOD and COD concentrations tended to be higher during the warmer months, reflecting a combination of decreased flow and an increased number of aquatic organisms.

During storm events, BOD concentrations, following an initial depression with the onset of rainfall, remained relatively constant during the storm period. In contrast, COD typically rose sharply after the initiation of rainfall and, after a short period of decline, increased again, paralleling the ascending limb of the hydrograph. These patterns suggest that much of the shock loading, i.e., those wastes which are rapidly removed from the surface or are already entrained in drainage channels, are biologically resistant organics and do not appreciably contribute to the biochemical oxygen demand. This is notable in consideration of the large amounts of decomposing vegetation and other BOD contributors normally present in the open drains.

Comparison of storm mean COD values shows stations 4 and 8a only slightly higher than other stations, despite their heavy concentration of industry, their known intrusion of sanitary wastes from both by-passes and septic tank areas, and their large percentage of open drainage channels. COD storm means for predominantly rural stations were only slightly less than those of urban stations. The similarity of COD values in both rural and urban areas are attributable to the nature of the test; i.e., leaves and sticks from rural areas may possibly elevate COD values to those levels noted in sewage-influenced urban areas. Moreover, at all stations COD storm mean values were slightly elevated over annual baseline means. In summary, storm related COD levels, although varying in their make-up, had an equivalent impact on the receiving stream concentrations throughout the monitoring network.

BOD values were typically depressed after storm events and failed to reflect a significant intrusion of significant quantities of biologically oxidizable wastes during periods of runoff. Stations 4 and 1, during the low intensity storm of December, were exceptions with significant increases in BOD values. It is possible that this storm was sufficient in intensity to move BOD materials into the receiving streams, but a low total rainfall spread over many hours did not appreciably dilute the BOD values. Storm BOD mean values were below the annual mean concentrations of baseflow sampling.

In comparing storms, little correlation is apparent for COD and BOD values with season, intensity or total rainfall amounts. Although the heavy storms of May and July tended to yield higher values for BOD and COD, there were numerous exceptions.

BOD and COD are important because they are measures of the potential oxygen consumption of a storm's organic load. These demands, however, typically require up to six days before they are expressed in diminished oxygen levels. With stream velocities of 40 miles/day for Caney Bayou and 16 miles/day for Bayou Bartholomew, and in the absence of appreciable upstream loading, the stream systems would not be expected to show an appreciable oxygen depletion following storm events. In short, the demands should be carried out of the Study Area long before oxygen depletion. Post-storm dissolved oxygen monitoring up to five days after a runoff period confirmed these expectations and showed no evidence of a decline in dissolved oxygen related to the storm event.

(6) Nutrients.

The various molecular species of organic and inorganic nitrogen and phosphorus are classified as aquatic nutrients. They can be readily absorbed or taken up by aquatic algae and often lead to explosive algal growths or blooms, which in turn accelerate the eutrophication process. Ammonia, nitrite, nitrate and Kjeldahl nitrogens, and total phosphorus were monitored during the baseline and storm sampling programs.

Ammonia results from the anaerobic reduction of nitrogenous matter and is often an indicator of the intrusion of untreated sewage. In many parts of the Study Area where agriculture is intensive, ammonia nitrogen enters the stream system as a result of the spring application of ammon nitrate and ammonium hydroxide. Although state standards have not bee established for concentrations of ammonia in Arkansas surface waters, has been reported that concentrations greater than 2.5 mg/l will induce fish kills as a result of the interference with oxygen uptake (McKee and Wolf, 1971).

Nitrite is an intermediate and short-lived molecular species in the oxidation of organic nitrogen to nitrate. Because it is quickly oxidized in the presence of oxygen, it is rarely present in significant quantities. State standards have not been established in Arkansas for nitrite. The presence of nitrite, as the presence of ammonia, is indicative of sanitary wastes which have very recently entered the stream system.

Nitrate is the end product of aerobic oxidation of organic nitrogen. Excessive nitrate levels occur as a result of partially treated sanitary wastes such as the effluent from oxidation ponds and intensive agricultural activity where nitrate is a common fertilizer. Arkansas has not established standards governing the concentrations of nitrate.

Ammonia, nitrite and nitrate nitrogen are essential for living systems but are pollutants in excessive concentrations. Nitrogen species move in and out of living systems through a complex series of both oxidation and reduction reactions making up the nitrogen cycle.

Total Kjeldahl nitrogen represents the total organic nitrogen such as protein material, plus ammonia. Thus, total organic nitrogen (TON) can be determined by subtracting the ammonia concentration from that of total Kjeldahl nitrogen.

Total phosphorus is also an essential element for living systems and its presence in the aquatic system can not be construed as pollution per se. Excessive levels of phosphorus in the form of phosphate are the result of partial treatment of sanitary wastes, industrial discharges, and the application of agricultural fertilizers. Because of the importance of many nitrogen species and total phosphorus as potential pollutants, they are treated collectively as nutrients.

Ammonia concentrations during the baseline sampling program ranged from 0.01 to 4.67 mg/l. High values as indicated by annual and seasonal means were found at stations 4 and 7 and most likely represented sanitary wastes from oxidation ponds and exfiltration. The low concentrations were found at stations 1, 2, 9a and b, and 10a, b and c. Seasonally, there were no consistent trends with the highs occurring in summer, fall and winter. During storm events, ammonia concentrations typically declined, although significant increases were recorded at Station 7 during the latter stages of the storm.

Nitrites were low throughout the baseline sampling program and ranged from 0.0 to 0.2 mg/l. In the majority of the individual samples, nitrites were undetectable. Storm events increased nitrite concentration at all urban stations with increased loading of partially oxidized waste water. Station 4 had the most pronounced increases and stations 1 and 5, whose drainage is primarily rural in character, had the lowest increases.

Nitrates within the baseline sampling program did not appear to correlate with urban-rural land use patterns. In annual means, Station 6 was the highest and Station 9b on Lake Pine Bluff was the lowest with values of 1.02 and 0.34 mg/l, respectively. Stations 4 and 5, despite their very different land use characteristics, were close in annual mean nitrate concentrations, as well as in comparisons of individual samples. Seasonal means at all stations were highest during the fall. Storm events increased nitrate concentration at all stations with the highest being recorded for stations 4, 7 and 8a. Moreover, storm related increases in nitrate were approximately equal in magnitude, despite differences in season, intensity and duration of the storm events.

Total Kjeldahl nitrogen resulting primarily from organic matter ranged from 0.1 to 6.4 mg/l. Highest annual means were recorded for stations 7 and 8a (2.6 and 2.44 mg/l, respectively). The lowest values were recorded for stations 1 and 2 (1.19 and 1.03 mg/l, respectively). In general, total Kjeldahl nitrogen correlated with known problems in sanitary waste disposal during baseflow, but there were several anomalies within the data due to the many different sources of organic matter. Seasonal trends were weak; the higher values tended to be recorded for the summer and fall, perhaps indicative of increased biological populations. Total Kjeldahl nitrogen increased sharply during storm events at all stations and formed one of the more distinct peaks over the course of the sampling period. The first increases correlated well with early increases in stage and suggest that much of the storm related total Kjeldahl nitrogen was already entrained and available for rapid transport to the receiving stream. The equally rapid return to baseline conditions also suggests that most of the transportable organic matter was quickly removed from the surface. In general, urban stations displayed the highest concentrations, with the highest storm mean recorded for Station 4 (2.7 mg/l). Variation in seasons and storm intensity did not yield significant differences in the values recorded for total Kjeldahl nitrogen.

Total phosphorus during both baseline and storm sampling increased with urbanization but perhaps, more specifically, with the problem of sanitary waste disposal. Throughout the baseline program, the total phosphorus ranged from 0.0 to 1.7 mg/l. The highest annual and seasonal means were recorded for Station 7 and represented in its annual mean a 685 per cent increase over that of Station 6, upstream. These consistently high phosphate values reflect, to a large extent, the final effluent of the upstream Caney oxidation ponds which ranged from 9 to 15 mg/l in total phosphorus; surface runoff from the Pine Bluff Arsenal may also be a contributor, however. Phosphorus levels in excess of the Arkansas State standards occurred in at least 10 per cent of the samples at all stations. The incidence of exceedance was low for stations 1, 6, 9a and 10a, b and c, and their annual means were below the State criteria. The urban stations all had annual means above the State required levels; stations 7 and 8a exceeded the criteria in more than 83 per cent of their samples. Decisive seasonal patterns were not apparent, although high values were most often recorded for the summer and fall months. Storm events accentuated baseline conditions, with all urban stations showing an increase in total phosphorus over the storm sampling period. Stations 7 and 8a displayed the highest increases (1.4 and 1.3 mg/l, respectively).

In summary, all monitored nutrients were high throughout the urban area, but not excessive, and were not positively correlated with problems in sanitary waste disposal.

(7) <u>Solids and Specific Conductivity</u>.

Total solids are the combined total of dissolved and suspended solids; each of which can be subdivided into volatile and non-volatile fractions.

Suspended solids represent suspended matter, most commonly silt and sediment which entered the stream through erosion or physical disturbance of the channel and bank. The toxic effects of suspended solids are more

physical than physiological. Abrasion and clogging of the respiratory and feeding apparatus of filter-feeding organisms such as molluscs are among the more common adverse effects. The covering of sessile or sedentary organisms is also an adverse physical affect produced by high suspended solid concentrations. During storm events, suspended solids are the dominant fraction of the total solid measurement, particularly in disturbed areas with poor soil stabilization. During baseflow, suspended solids are generally a minor component of total solids, except where there are ongoing construction activities.

In the baseline sampling program, stream stations were generally low in suspended solids throughout the year, with a range of 0 to 177 mg/l and possessed a combined average of 28 mg/l. High values (above 80 mg/l) were noted sporatically at all stream stations. The lake stations were generally lower in suspended solids than were those of the streams, except for mid-summer concentrations at Station 9b which were associated with construction on the eastern levee of the lake. During storm events, suspended solids increased by several hundred per cent at each monitored station. Station 2, with its channelization work and absence of bank stabilization, had the highest increases and the highest combined storm mean concentration (836 mg/l). Station 2 was followed by stations 8a and 4, with storm means of 383 and 259 mg/l, respectively; both stations drain the interior of the city and lands associated with construction activity. Suspended solid levels were directly correlated with storm intensity and duration.

Volatile solids are a subset of total suspended solids and are an indicator of organic matter; a few inorganic substances are also measured by the test, but their contribution is usually small. Throughout the baseline sampling program, volatile solids ranged from 16 to 148 mg/l, but in annual mean comparisons there were only slight differences between the stream stations. Stations 4 and 8a recorded the highest annual means (70mg/l) and possibly reflect an increase of organic matter with the intrusion of untreated sanitary waste. Lake stations were generally higher than the stream stations, with the annual mean of stations 10 a, b, and c equivalent to those recorded for stations 4 and 8a. Storm events produced only a slight increase in the volatile solid fraction of storm waters. The highest increases were recorded for the urban stations. Throughout both baseline and storm sampling programs, the volatile solids increased during the warmer months with increased numbers of biological organisms.

Dissolved solids represent both inorganic and organic molecular species in solution. They are objectionable in high quantities as they can cause corrosive damage to water systems, form scale in boilers, impart bad taste and produce a laxative effect on new users. Water with concentrations of dissolved solids greater than 500 mg/l may be unsuitable for irrigation purposes.

Although dissolved solids were not calculated, examination of the data for total and suspended solids shows clearly that none of the individual samples in the baseline program exceeded the state maximum allowable levels. Subtraction of the annual means for suspended solids from those of total solids indicate that stations 4 and 8a were high among the stream stations, with values of 144 and 152 mg/l, respectively. Employing the same

calculations, the lake stations were higher than those of the streams and stations 10a, b and c had the highest dissolved solid concentrations with an estimated mean of 212 mg/l. During storm events, examination of the runoff data showed a significant increase in dissolved solid concentrations occurred primarily at stations 2 and 4; at both stations the maximum storm level exceeded the criteria established for Bayou Bartholomew, but not those of unspecified tributaries.

Specific conductance, a measure of the electrolytic fraction of dissolved solids, was positively correlated with dissolved solids and displayed the same trends from station to station. Throughout the baseline sampling program, specific conductance ranged from a low of 30 micromhos/cm at several stream stations to a high of 560 micromhos/cm at stations 10a, b and c. During storm events, specific conductance declined at all stations over the sampling period. This suggests that the storm related increases in dissolved solids noted for stations 2 and 4 were non-electrolytic and probably of organic origin.

(8) Specific Minerals.

During the latter part of the baseline sampling program, three complete sets of samples were taken of sodium, sulfate, chlorides, iron and manganese. Although too few samples were taken to indicate definitive trends, some general patterns were indicated. Generally, among the stream stations, stations 4, 7, and 8a were the most highly mineralized, with high concentrations of sodium, sulfate and manganese. Chlorides and iron were generally comparable at all stream stations. The lake stations were generally higher in mineral concentrations than were the stream stations and the sampling points at stations 10a, b and c, coming under the influence of the Arkansas River, were the most highly mineralized of all of the individual sampling stations. In terms of specific standards, no exceedance occurred during the period of sampling at any station.

(9) Hardness.

Hardness represents the total concentration of calcium and magnesium ions expressed as calcium carbonate. However, if other hardness producing polyvalent metals such as aluminum, iron, manganese and zinc are present in significant amounts, they should also be included (American Public Health Association, 1971). There are no State standards for hardness for surface waters. The hardness trends and relative positioning of the stations corresponded closely to those for total solids, dissolved solids and specific conductance. There was nearly a linear relationship between calcium and total hardness. Only the latter will be discussed. The range throughout the baseflow program was 11 to 106 mg/l calcium carbonate and, in general, the lake systems were higher in total hardness than were the stream systems. The individual samples from stations 10a, b and c were consistently above 60 mg/l with annual means of 92, 90 and 102 mg/l, respectively. Among the stream stations, stations 4 and 8a had the highest annual means (64 and 57 mg/l, respectively) and possibly reflect the discharge of industrial waste waters, such as the daily release of iron-rich water to Station 2. Storm events depressed hardness values at all storm sampling stations, presumably as a result of rain water dilution.

(10) Oils and Grease.

Oils and grease in solution or as an emulsion on surface waters are usually indicative of industrial activity, although natural seepage, runoff from residential areas and decomposition of aquatic organisms may also be contributors. Waters with a persistent surface film of oils and grease will generally be low in dissolved oxygen due to reduction in aeration rates and photosynthetic activity. Oils and grease as a non-polar solvent may also interfere with many of the natural physicochemical relationships of the water system.

Oil and grease levels throughout the baseline sampling program were generally low and ranged from 0.0 (many stations) to 37.1 mg/l (Station 9a); the highest annual means were recorded at stations 9a and 4 (3.96 and 2.75 mg/l, respectively). Although Station 1 and the stations on Lake Langhofer (stations 10a, b and c) were among the lowest in annual means, concentrations of oils and grease did not correlate well with land use. Stations 5 and 6, although primarily rural in drainage characteristics, were higher in annual mean concentrations of oils and grease (1.23 and 1.15, respectively) than was Station 8a which was located in a highly industrialized area. During storm events, oils and grease increased sharply, coincident with significant increases in stage. Elevated concentrations were recorded at all stations, but again, correlations with land use were weak; Station 2 had the highest aggregate storm mean.

c. Baseflow and Stormwater Quality by Station.

This section summarizes the water quality of each sampling station. All data and graphs for this section are appended (Appendix C).

(1) Arkansas River Basin.

(a) Caney Bayou System.

1. Station 6 (Upper Caney).

A summary of baseflow water quality is appended (Table C-52). Stormwater was not sampled at Station 6. In keeping with the rural character of its drainage area, the baseflow water quality was generally good; indicators of pollution concentrations were among the lowest recorded. Occasional high concentrations of both fecal coliform bacteria and nitrates occurred, however, suggesting that sanitary wastes were entering Caney Bayou upstream of Station 6. The absence of ammonia or nitrite and the low levels of BOD and COD also suggest that these wastes are well oxidized and entering at some distance from the station. The elevated fecal coliform bacteria levels occurred in all seasons and were of sufficient magnitude to prohibit contact recreation. The remaining water quality parameters were well within accepted standards and would not be limiting to the naturally occurring biological community or other uses designated for Class B waters (Section IV. B.5.).

2. Station 7 (Lower Caney).

Summaries of baseflow water quality and stormwater quality are appended (Tables C-53, C-65). Consistently high levels of nutrients (especially phosphorus), biochemical oxygen demand (BOD) and dissolved solids were the most salient water quality characteristics of Station 7. These, for the most part, were reflections of the effluents of two upstream sanitary oxidation ponds and two industrial waste oxidation ponds (Section IV.B.4.). Comparison of flows and effluent sampling (Section IV.B.4.) indicated, however, that the sanitary oxidation ponds were responsible for at least 60 to 70 per cent of the nutrient, organic and solid levels above those of the natural background. Accompanying these high pollution loads are prolonged periods of low baseflow dissolved oxygen levels throughout the warmer months. The levels of total phosphorus and nitrogen (all species) were the highest recorded for baseflow sampling and phosphorus levels exceeded Arkansas standards in 83 per cent of the samples. Nutrient enrichment was, unquestionably, the most serious problem of Station 7 and is responsible for much of the structure and composition of its biological community (Section VI.B.). The fecal coliform bacteria levels, while elevated, were surprisingly moderate in relation to other stations and only slightly increased over the counts of Station 6; even in storm events, the fecal bacteria levels remained relatively moderate. Apparently, influence of the upstream Caney oxidation ponds upon fecal bacteria levels was insignificant. However, they are sufficient to restrict any contact recreation or activities. Storm events increased fecal coliform and fecal streptococcus bacteria levels, but lowered and held constant the levels of nutrients, organics and solids.

(b) Brumps System.

1. Station 8a (Brumps Bayou).

Summaries of baseflow water quality and stormwater quality are appended (Tables C-54, C-66). The concentrations of fecal bacteria, nutrients, organics and solids were high to excessive for the baseflow and stormwaters of Station 8a and will impact the lower end of Brumps Bayou adjoining Lake Pine Bluff. Overall, the water quality of Station 8a was poor, often exceeding State criteria, and severely limiting to aquatic life and potential uses for recreation and industry. As detailed in Section IV.B.4., the sources of pollution are numerous but center around industrial runoff, erosion of poorly vegetated lands, and storm and steady-state sanitary waste discharges. Although not adequately captured in the water quality data, high oil and grease levels were a frequently observed problem and dissolved oxygen levels often dipped to less than 1 mg/l. Fish kills at Station 8a and below occurred in the spring of 1974.

2. Station 8b (Brumps Confluence).

Station 8b was monitored only for fecal coliform bacteria, fecal streptococcus bacteria and BOD during storm events (Table C-67 appended). Aside from the drainage of open areas in the northern portion of the sub-basin, the major source of stormwaters is the discharge of the Barraque and Spruce streets pumping station (Figure IV-3). Expectedly, the BOD levels and fecal coliform and streptococcus bacteria concentrations were high.

3. Station 9a (Lake Pine Bluff, west).

Station 9a is located at the confluence of Brumps Bayou at the mouth of Lake Pine Bluff. A summary of its baseflow water quality is appended (Table C-55). Storm events were not monitored. Fecal coliform and fecal streptococcus bacteria at Station 9a were elevated and during all seasons would limit the water uses for this section of the lake. Suspended solids were also high; the highest recorded for baseflow sampling. This too reflects the influence of Brumps Bayou. Surprisingly, nutrient and organic levels were relatively low and perhaps reflect uptake and oxidation in the relatively quiet and heavily vegetated waters. Inversions (depressed oxygen levels on the upper part of the water column) were a frequent occurrence.

In summary, the water quality of Station 9a was transitional between the poor water quality of Brumps Bayou and the relatively good water quality of Lake Pine Bluff; its salient pollutional problems are fecal bacteria and sediment. The data and conclusions for both lake stations, however, must be quantified with the draw-down and fertilization of the lake during the summer of 1974.

4. Station 9b (Lake Pine Bluff, east).

Located along the western edge of Lake Pine Bluff, Station 9b had generally good water quality. A summary of the baseflow water quality is appended (Table C-56); stormwater was not monitored at Station 9b. Organic nitrogen, as expressed by total Kjeldahl nitrogen, was elevated slightly and there were sporadic increases in suspended solid concentrations. The nitrogen values perhaps reflected the concentration of algae accompanying the drawdown and the solids reflected construction on the eastern levee.

(c) Arkansas River System - Stations 10a, b and c (Lake Langhofer).

All three stations are comparable and are discussed below as a unit. Summaries of the baseflow water quality data are appended (Tables C-57, C-58, C-59). Stormwaters were not monitored. The water quality of Lake Langhofer was generally good and low fecal coliform bacteria levels make it well suited for recreational use. The lake, however, receiving the majority of its waters from the Arkansas River, was highly mineralized and thus limited in its industrial use potential. Stratification was evident during the summer, but weak. Dissolved oxygen levels were good throughout the water column except during the warmer months, when much of the lower portion of the column exhibited less than 5 mg/l. This was especially pronounced at Station 10b (Boyd Point) and may reflect demands from the waters of Caney Bayou which enter to the west of Station 10b, leakage from the sanitary force main, and/or fecal matter from nearby pasturelands.

(2) Ouachita River Basin.

(a) Bartholomew System.

1. Station 1 (Bayou Bartholomew at Princeton Pike).

Princeton Pike lies near the headwaters of Bayou Bartholomew and is primarily rural in its drainage. Summaries of the baseflow water quality and stormwater quality are appended (Tables C-47, C-60).

Fecal coliform and fecal streptococcus bacteria were present at all samplings and, except for the summer months, were generally low. The summer fecal coliform bacteria levels indicated that samples would frequently exceed State standards; the summer fecal streptococcus bacteria mean was the highest recorded for Bayou Bartholomew and its tributaries. Fecal coliform bacteria levels in the stormwaters of both monitored storms were in excess of State standards. The bacteria levels of Station 1 were most likely the result of animal wastes from upstream pasturelands and would limit the recreation potential of the stream. BOD and COD were generally low and comparable to other Bartholomew stations. Increases in organics occurred during the warmer months, presumably in response to increased grazing activity. Storm events also tended to increase COD levels, suggesting that much of the organics of runoff were biologically resistant. Nutrient levels and solids were low and the concentration of all other baseflow and stormwater quality parameters were well within accepted limits.

2. Station 2 (Interceptor Canal).

Station 2 drains developed areas and derives much of its flow from the discharge of ground water by General Waterworks. The baseflow water quality of Station 2 was generally good.

Summaries of baseflow water quality and stormwater quality are appended (Tables C-48, C-61). During baseflows, suspended solids were elevated and then only for the latter part of the sampling program accompanying channel improvements. Fecal coliform bacteria levels only occasionally gave evidence that State criteria would be exceeded and dissolved oxygen levels were the highest of all Bartholomew stations. The total phosphorus level, however, was, in its annual mean, above State recommended levels.

Stormwater quality analysis, in contrast to that of baseflows, revealed appreciable concentrations of fecal bacteria and suspended solids. The former resulted from a number of sanitary problem areas within the drainage sub-basin and the latter was a reflection of poor bank stabilization and severe erosion. Accompanying the storm intrusion of sanitary wastes and sediment were elevated concentrations of nutrients and organics.

3. Station 3 (Bayou Bartholomew at Highway 15).

The composition of the drainage area of Station 3 is of mixed character. Station 3 is located downstream from the mouth of Interceptor Canal. Summaries of baseflow water quality and stormwater quality are appended (Tables C-49, C-62). The concentrations of fecal bacteria at Station 3 were low to moderate during baseflow and moderate during storm events. Overall, however, the bacteria levels were sufficient to restrict contact recreation in this reach of Bayou Bartholomew. Baseflow suspended solids were low but comparable to those of Station 2; solid levels during storm events were only slightly elevated in comparison to the levels recorded for stations 2 and 4. Nutrient and organic concentrations were moderate for both monitored flow regimes, but storm phosphorus levels were well above State criteria. Dissolved oxygen levels were generally within acceptable limits.

4. Station 4 (Outlet Canal).

Outlet Canal drains a mixture of developed and semi-rural areas and, overall, the water quality was exceptionally poor. Summaries of baseflow water quality and stormwater quality are appended (Tables C-50, C-63). Although the pollution sources are not well drained, sanitary wastes and storm sedimentation were seemingly the most salient problems. Fecal bacteria of baseflows were high and the majority of samples indicated that exceedance of State standards could occur. Stormwater fecal bacteria concentrations were second only to those of Station 8a and all stormwaters exceeded State standards. Nutrient levels and organics were also elevated during baseflows and storm events and must be attributed to sewage.

Nitrogen and phosphorus levels were comparable only to those of Station 7; the latter in all stormwater samples and in 71 per cent of baseflow samples exceeded State recommended levels. BOD and COD were elevated in both sampling regimes and dissolved oxygen levels of baseflows were consistently low and below standards. Oils and grease were visible and were the highest recorded for the baseflow sampling program. The oil and grease concentrations increased during storm events and are probably attributable to runoff from impervious urban surfaces. Solid concentrations (total, suspended and volatile) were appreciably elevated during storm events and second only to those of Station 2. The origins of the solids were difficult to fix but, perhaps, result from urban construction activities such as Highway 65 and the Convention Center, and from runoff from adjacent agricultural fields.

Station 4 was severely polluted in comparison to the monitored stations of the Study Area and nationally, the quality of the stormwaters was on a par with those of much larger cities (see Table IV-1). Although Outlet Canal currently is being used only for drainage, the quality of its waters would severely limit any additional uses planned for the future.

5. Station 5 (Bayou Bartholomew at Pinebergen).

Station 5 is located several miles downstream from the mouth of Outlet Canal and its drainage area is basically rural. The overall water quality is good. Summaries of baseflow water quality and stormwater quality are appended (Tables C-51, C-64). Baseflow fecal bacteria were among the lowest recorded for Bayou Bartholomew and indicate that distance and dilution ameliorated much of the upstream sanitary waste pollution. Only occasionally would contact recreation be limited. Storm events, however, elevated fecal coliform bacteria and exceedance of State criteria occurred during these periods. Baseflow and storm event nutrient levels were moderate. They were most pronounced during the summer and fall and reflect a combination of increased biological production and die-off, as well as upstream contributions. Organics were low to moderate and dissolved oxygen levels were comparatively high.

The water quality of Station 5 indicates that the overall pollutional contribution of the Study Area to the lower reaches of Bayou Bartholomew is nominal during baseflow and only slightly increased during storm events. As discussed in Section VI.B., biological populations are

somewhat less diverse than upstream; this may be more reflective of unmonitored phenomena such as pesticide "slugs" rather than increased "pollution" *per se*.

d. Storm Loading.

Storm loadings were prepared for the storm of July 25-26, 1974, for seven water quality parameters at three urban stations (2, 4 and 8a). The seven parameters evaluated were: BOD, COD, total Kjeldahl nitrogen, nitrate, total phosphorus, total solids and zinc. This storm was chosen because it represented one of the most intense of the monitored storms (Table IV-14) and rainfall amounts were well over two inches. The individual loading curves and the methodology for their derivation are appended (Appendix C.).

To compare the three urban stations, Table IV-19 presents the cumulative storm loads for a 10-hour (600 minute) period following the onset of rainfall and Table IV-20 presents these total loadings as contributions per square mile of drainage area. Although the hydrograph of each station (Appendix C.) is different in shape and time-to-peak-discharge, the 10-hour period was selected as it appeared to represent a point where each station was most favorably comparable in its discharge relationships. Moreover, as indicated by the individual cumulative loading graphs and "pollutographs" (Appendix C.), after 10 hours the majority of the storm's pollution load had been received by the stream.

As indicated by Table IV-19, Station 4, monitoring several urban sub-basins, had, with the exception of total solids, the largest pollution loads. The elevated total solids of Station 2 represent primarily suspended solids accompanying severe erosion and the absence of bank stabilization.

The loads adjusted to the contribution of each square mile of drainage area (Table IV-20) reveal that, with the exception of the solid contribution of Interceptor Canal, each of the three stations were very comparable. Interceptor Canal was also slightly lower in organics but elevated in total Kjeldahl nitrogen. The latter most likely represents organic nitrogen introduced with the solids.

e. Analysis of Baseflow and Stormwater Quality and Land Use.

The correlation of land use and water quality is complex and even the most rigorous statistical procedures have often failed to yield usable correlations and explanations of variability. This frequently occurs when a single pollution source dominates the water quality at a given monitoring station. In the present study, the following analysis of land use effects upon water quality is qualitative and subjective. It takes into consideration the findings of previous analyses (Section IV.B.2.), existing land use (Section III) and the identifiable pollution sources (Section IV.B.4.). Although limited in scope, this section lays the foundation for the projections of stormwater quality presented in Section IV.F. Only those parameters which constituted a significant pollutional problem are addressed.

TABLE IV-19
July 25-26, 1974, Cumulative Storm Loads

| PARAMETER | CUMULATIVE POUNDS PER 10 HOURS OF STORM DISCHARGE | | |
|---|---|---|---|
| | STATION NO. | | |
| | 2* | 4 | 8 |
| BOD | 1,140 | 4,000 | 1,420 |
| COD | 4,870 | 17,400 | 5,500 |
| Total Kjeldahl Nitrogen | 507 | 1,400 | 310 |
| Nitrate | 86 | 420 | 130 |
| Total Phosphorus | 30 | 110 | 27 |
| Total Solids | 277,000 | 190,000 | 39,000 |
| Zinc | 19 | 30 | 16 |

*Values at Station 2 expanded to 10 hours.

TABLE IV-20
July 25-26, 1974, Storm Load Contributions
Per Square Mile of Drainage Area

| PARAMETER | POUNDS PER SQUARE MILE OF DRAINAGE AREA | | |
|---|---|---|---|
| | STATION NO. (DRAINAGE AREA) | | |
| | 2 (2.36 $mi^2$) | 4 (6.99 $mi^2$) | 8 (1.8 $mi^2$) |
| BOD | 483 | 572 | 789 |
| COD | 2,064 | 2,489 | 3,056 |
| Total Kjeldahl Nitrogen | 215 | 200 | 172 |
| Nitrate | 36 | 60 | 72 |
| Total Phosphorus | 13 | 16 | 15 |
| Total Solids | 117,373 | 27,182 | [illegible]1,667 |
| Zinc | 8 | 4 | 9 |

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(1) Fecal Coliform and Fecal Streptococcus Bacteria (Fecal Bacteria).

Baseflow levels of fecal bacteria corresponded with unsewered areas as those found in the Brumps Bayou, Outlet Canal and rural drainages (Figure IV-3) and only indirectly with the extent of urbanization. Moreover, both the Brumps and Outlet drainage areas contained most of the older sewer lines in the metropolitan area with identified problems of exfiltration (Section IV.B.4.). Stormwater bacterial levels seem to be more closely correlated with urbanization, but this may be fortuitous as storm related sanitary problems, such as surcharges and pumping station by-passes, are found throughout the metropolitan area (Section IV.B.4.). The effluent of oxidation ponds (viz. Lower Caney), while significant in their contributions, produced only moderate baseflow and storm levels of fecal bacteria.

(2) BOD and COD (Organics).

Consistent with other studies, organic levels correlated weakly with land use categories and specific pollution sources. Baseflow and stormwater highs corresponded with the most severely polluted stations as indicated by fecal bacteria (stations 4 and 8a).

(3) Nitrogen and Phosphorus (Nutrients).

During baseflow, nutrients correlated with sanitary wastes and were particularly pronounced downstream of the effluent of the Caney oxidation ponds (Station 7). During storm events, nutrient levels increased in relation to storm related discharges of sanitary wastes and sediment.

(4) Solids (Suspended and Volatile).

Baseflow suspended solids were highest in drainage systems with poor bank stabilization (Brumps and Interceptor). Volatile solids, however, were correlated best with identified steady-state problems in sanitary wastes. Storm events increased the concentrations of both solid categories and, in general, best correlated with the degree of urbanization and all of its attendant pollution potentials.

(5) Metals (Zinc, Mercury and Lead).

Storm levels of mercury were insignificant, but zinc and lead storm concentrations corresponded closely to levels of suspended solids. High values were recorded for all urban stations.

(6) Oils and Grease.

Baseflow oils and grease levels were best described by degree of urbanization; storm values showed no apparent correlations.

## C. HEAVY METALS AND PESTICIDES.

This section examines the concentrations and possible consequences of heavy metals and pesticides detected in water, sediment and biological tissues at selected stations within the Study Area. The various sampling programs and results are appended (Appendix C.).

### 1. Heavy and Trace Metals.

Concentrations of metals such as nickel, cobalt, iron, manganese, cadmium, copper, chromium, silver, zinc, lead and mercury in surface and subsurface waters, sediment and animal tissues are usually attributable to four major sources: natural occurrence, industrial effluents, domestic wastes and erosion from agricultural and urban lands. In natural waters, most metals occur in very low concentrations and are necessary for healthy and balanced populations of aquatic life. Higher concentrations of iron, zinc and manganese can exist naturally in the presence of poorly-buffered, acidic waters (Ruttner, 1952) such as are often found in the Study Area.

Metals can interfere with industrial processes, make drinking water undrinkable and upset physiological functions of biota. Relatively little is known regarding effects of varying metal concentrations upon the latter. For instance, toxicity of metal salts toward aquatic life varies widely with the species, temperature, pH, hardness and synergistic and antagonistic properties of the metal. Papers dealing with acute and chronic toxicities to aquatic and terrestrial biota include those of McKee and Wolf (1971), Cairns and Scheier (1957), Snyder et al. (1973), Faber and Hickey (1973), Dustman et al (1972), Trama (1954), Brungs (1969) and Doudoroff and Katz (1953). In addition, an excellent bibliography by the U.S. Environmental Protection Agency (1973) deals with the biological effects of metals in aquatic environments.

The results of non-periodic or grab water samples is presented in Tables IV-21 and IV-22. Sediment analytical results are presented in Table IV-23 and those of biological tissues are presented in Tables IV-24 and IV-25.

#### a. An Overview.

Significant levels of iron and manganese were detected in baseflow water samples at most stations; lower levels of mercury, barium and arsenic were also detected at most stations. The levels of iron and manganese can generally be attributed to redox conditions and those of barium to natural origins; the origins of mercury and arsenic levels are conjectural. Arsenic and mercury were generally not detected in mud samples. Zinc and lead exhibited the highest concentrations in mud samples, followed by copper, chromium, silver and cadmium. Concentrations of zinc were higher than lead in all fish samples. No pattern of biomagnification, with the exception of copper in the green sunfish, was noted for herbivorous or carnivorous fishes. With several exceptions, mammalian and avian metal concentrations were similar to or lower than those of fishes taken in similar areas. The exceptions were owls and raccoons taken in areas adjacent to agricultural croplands. Use of pesticides,

TABLE IV-21
Heavy and Trace Metals Detected in Study Area Waters

| PARAMETER AND CONCENTRATION | STATION NUMBER | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8a | 9a | 9b | 10a | 10b | 10c |
| Barium (ug/l) | 500 | 310 | 340 | 290 | 380 | 350 | 340 | 290 | 300 | 100 | 2 | 100 | 50 |
| Selenium (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Beryllium (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Antimony (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Molybdenum (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Thallium (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Tin (ug/l) | 10 | 15 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Titanium (ug/l) | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Mercury (ug/l) | 0 | 3 | 1 | 0 | 0 | - | 1 | - | 0 | - | - | 1 | - |
| Zinc (mg/l) | < .03 | .05 | < .03 | < .03 | < .03 | - | < .03 | - | < .03 | - | - | < .03 | - |
| Lead (mg/l) | < .03 | < .03 | < .03 | < .03 | < .03 | - | < .03 | - | < .03 | - | - | < .03 | - |
| Cadmium (mg/l) | < .05 | < .05 | < .05 | < .05 | < .05 | - | < .05 | - | < .05 | - | - | < .05 | - |
| Silver (mg/l) | < .05 | < .05 | < .05 | < .05 | < .05 | - | < .05 | - | < .05 | - | - | < .05 | - |
| Arsenic (mg/l) | .01 | .00 | .00 | .01 | .01 | - | .02 | - | .01 | - | - | .00 | - |
| Copper (mg/l) | < .05 | < .05 | < .05 | < .05 | < .05 | - | < .05 | - | < .05 | - | - | < .05 | - |
| Chromium (mg/l) | < .05 | < .05 | < .05 | < .05 | < .05 | - | < .05 | - | < .05 | - | - | < .05 | - |
| Cyanides (mg/l) | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 |
| Boron (mg/l) | .04 | .06 | .04 | .09 | .00 | .07 | .15 | .35 | .01 | .01 | .06 | .08 | .04 |
| Phenols (mg/l) | < .1 | .7 | < .1 | < .1 | < .1 | < .1 | 1.6 | < .1 | < .1 | < .1 | < .1 | < .1 | < .1 |
| Aluminum (mg/l) | .09 | .58 | .23 | .07 | .11 | .27 | .10 | .04 | .80 | .11 | .10 | .10 | .13 |
| Nickel (mg/l) | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 |
| Cobalt (mg/l) | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 | < .10 |
| Manganese (mg/l) | 0.7 | 0.0 | 0.5 | 1.2 | 2.3 | .9 | 0.8 | .15 | 0.2 | .73 | < .05 | 0.0 | .02 |
| Iron (mg/l) | 2.9 | 2.7 | 1.2 | 2.5 | 2.5 | 3.2 | 1.1 | 1.4 | 0.6 | 2.6 | < .05 | 0.2 | .12 |

TABLE IV-22
Means and Concentration Ranges (mg/l) for Zinc, Lead and Mercury in Stormwaters

| PARAMETER | | STATION NUMBER 1 | 2 | 3 | 4 | 5 | 7 | 8a |
|---|---|---|---|---|---|---|---|---|
| Zinc | Range | 0.04 -0.12 | 0.04 -0.28 | 0.04 -0.17 | 0.03 -0.25 | 0.05 - 0.10 | <0.05 -0.12 | <0.05 -0.29 |
| | Mean | 0.07 | 0.14 | 0.10 | 0.10 | 0.07 | 0.04 | 0.13 |
| Lead | Range | <0.10 -0.30 | <0.05 -0.20 | <0.05 -0.10 | <0.05 -0.20 | <0.05 -0.20 | <0.05 - 0.20 | <0.50 -0.30 |
| | Mean | 0.07 | 0.08 | 0.03 | 0.05 | 0.05 | 0.06 | 0.08 |
| Mercury | Range | 0.000-0.003 | 0.000-0.003 | 0.000-0.004 | 0.000-0.003 | 0.000-0.003 | 0.000-0.002 | 0.000-0.005 |
| | Mean | 0.001 | <0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 |

TABLE IV-23
Heavy Metal Concentrations in Sediment at Study Area Stations

| SAMPLING STATION | METAL AND CONCENTRATION (ug/g) Ag | Cd | Zn | Cu | Cr | Pb | As | Hg |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 36 | 5 | 6 | 23 | 0 | 0 |
| 2 | 3 | 3 | 39 | 5 | 5 | 21 | 1 | 0 |
| 3 | 3 | 3 | 83 | 10 | 15 | 191 | 0 | 0 |
| 4 | 3 | 3 | 153 | 16 | 21 | 174 | 0 | 0 |
| 5 | 3 | 3 | 80 | 32 | 11 | 27 | 0 | 0 |
| 7 | 3 | 3 | 53 | 12 | 11 | 17 | 0 | 0 |
| 9a | 3 | 3 | 72 | 22 | 5 | 31 | 0 | 0 |
| 10b | 3 | 3 | 77 | 15 | 15 | 26 | 0 | 0 |

TABLE IV-24
Heavy Metal Concentrations in Fishes at Study Area Stations

| STATION NUMBER | SPECIES | HEAVY METAL AND CONCENTRATIONS* (ug/g) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ag | Cd | Zn | Cu | Cr | Pb | As | Hg |
| 1 | Golden Shiner | All less than 2 ug/g | All less than 2 ug/g | 34 | <5 | All less than 5 ug/g | 10 | All 0 ug/g | All 0 ug/g |
| | Green Sunfish | | | 23 | <4 | | 17 | | |
| 2 | Golden Shiner | | | 27 | <4 | | 12 | | |
| | Green Sunfish | | | 21 | <5 | | 9 | | |
| 3 | Gizzard Shad | | | 20 | <4 | | <9 | | |
| | Bluegill | | | 27 | <5 | | 14 | | |
| 4 | Golden Shiner | | | 11 | <4 | | 9 | | |
| | Orangespotted Sunfish | | | 24 | <5 | | <10 | | |
| 5 | Gizzard Shad | | | 14 | <5 | | <9 | | |
| | Warmouth Sunfish | | | 14 | <5 | | <10 | | |
| 7 | Golden Shiner | | | 34 | <5 | | <9 | | |
| | Green Sunfish | | | 34 | 10 | | <10 | | |
| 9a | Golden Shiner | | | 28 | <4 | | <9 | | |
| | Bluegill | | | 17 | <4 | | <8 | | |
| 10b | Gizzard Shad | | | 19 | <4 | | <9 | | |
| | Longear Sunfish | | | 27 | <4 | | <8 | | |

* Mercury is ug/g of dried sample.

TABLE IV-25
Heavy Metal Concentrations in Raccoon and Owl Livers at Study Area Stations

| STATION NUMBER | SAMPLE | HEAVY METAL AND CONCENTRATION (ug/g) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ag | Cd | Zn | Cu | Cr | Pb | As | Hg |
| 1 | Barred Owl | <3 | <3 | 196 | 7 | <5 | <5 | 0 | <1 |
| | Raccoon | <2 | <2 | 21 | <4 | <4 | 9 | 0 | 0 |
| 3 | Barred Owl | <2 | <2 | 25 | <4 | <4 | <8 | 0 | - |
| | Raccoon | <2 | <2 | 26 | <4 | <4 | <9 | 0 | 0 |
| 5 | Screech Owl | <4 | <4 | 19 | <8 | <8 | <17 | 0 | - |
| | Raccoon | <2 | <2 | 57 | 17 | <4 | <4 | 0 | <1 |
| 7 | Screech Owl | <13 | <13 | 58 | 15 | <25 | <25 | 2 | <1 |
| | Raccoon | <2 | <2 | 51 | 13 | <5 | <5 | 0 | <1 |
| 9a | Screech Owl | <12 | <12 | 30 | 39 | <25 | <25 | 2 | <1 |
| | Raccoon | <2 | <2 | 32 | 13 | <4 | <4 | 0 | <1 |
| 10b | Screech Owl | <11 | <11 | 70 | 13 | <5 | <5 | 1 | <1 |
| | Raccoon #1 | <2 | <2 | 101 | 18 | <4 | 9 | 0 | 1 |
| | Raccoon #2 | <2 | <2 | 28 | 8 | <4 | <4 | 0 | <1 |

herbicides and fungicides is assumed to be the primary contributing factor to metal bioconcentration in the Study Area. Effects of heavy metal bioconcentration upon aquatic species diversity or upon individual mammalian or avian vigor is unknown. However, in a national framework, the problems of metals uptake and biomagnification do not appear to be significant in the Pine Bluff Study Area.

b. Metal Concentrations in the Arkansas River Basin.

(1) Station 6 (Upper Caney Bayou).

Only the metals of the water column were examined at Station 6 and only once during the period of study (Table IV-21). Of the analyzed metals, only barium, iron and manganese were found at significant levels. The concentrations of these metals are most probably the result of natural phenomena.

(2) Station 7 (Lower Caney).

Barium, mercury, manganese, iron and arsenic were detected in baseflow water samples taken at Station 7 (Table IV-21). The concentrations of these metals, except mercury, are probably due to natural phenomena. The origin of mercury here is unknown. Given the near-anaerobic condition of the stream during sampling, the manganese and iron concentrations are quite low. Mercury, zinc and lead concentrations in stormwaters were similar to or lower than those of other stations (Table IV-22). Metal concentrations in sediment samples were similar to those stations relatively unaffected by agricultural runoff (Table IV-23).

Biomagnification of copper occurred in green sunfish, screech owl and raccoon tissue samples (Tables IV-24 and IV-25). Copper may enter the Caney Bayou System via the effluent weirs at two oxidation pond systems upstream. As agricultural cropland activities in the Caney System are very limited, the copper concentrations cannot be equated with agriculture in this watershed. Copper and zinc concentrations in the screech owl and raccoon cannot necessarily be attributed to activities in the Caney System; a more acceptable explanation would be that these predators ingested organisms in the open and wooded bottomlands and agricultural areas in the nearby Arkansas River watershed, where pesticides applications containing heavy metals would be more likely.

Arsenic was detected in water during low-flow conditions at a concentration higher than at any other station (Table IV-21). However, no arsenic was detected in sediment or fish tissues. A level of 2 ug/g arsenic was detected in a screech owl liver sample. The likely source of this metal appears to be possible predation by the owl in nearby agricultural areas.

(3) Station 8a (Brumps Bayou).

Despite the industrial areas of the Brumps Bayou drainage area, metals were not a prominant part of the water quality of Brumps Bayou. Iron, manganese, barium and aluminum were detected, but at levels comparable to other stations.

(4) Station 9a (Lake Pine Bluff).

Low concentrations of iron, manganese and arsenic were detected in water samples at Station 9a (Table IV-21). Both iron and manganese probably were precipitated out of the water column as hydroxides, as high dissolved oxygen and pH values and subsequent low free $CO_2$ concentrations existed during the July 18 period. Arsenic was not detected in sediment at Station 9a (Table IV-23); but was detected in a screech owl liver (Table IV-25). This specimen may have accumulated this metal by feeding in nearby croplands.

Zinc, copper and lead were detected in mud at Station 9a (Table IV-23). Levels of zinc and lead carried into the system during storm events were similar to those recorded at Station 2 (Table IV-22). Zinc concentrations in fishes monitored at Station 9a were comparable with those of other stations. Raccoon and screech owl liver samples contained levels of copper and zinc similar to those of the specimens taken from the Station 7 area (Table IV-25), with copper concentrations in the screech owl at this station the highest recorded of any organism sampled in the Study Area. As the owl and raccoon specimens from stations 7 and 9a were taken in close prosimity to one another, the origins of their metal may be similar.

(5) Station 10b (Lake Langhofer).

Mercury and iron were noted in water samples at Station 10b in low concentrations (Table IV-21). Supersaturation of dissolved oxygen was noted in the top of the water column on July 25, 1974, and little or no manganese or iron was found. The mercury concentration (0.001 mg/l) of the water was similar to that detected at several other stations. Upstream agricultural activities or industrial wastes probably account for mercury concentrations in water at this station.

Levels of zinc, copper, chromium and lead in sediment samples were similar to those detected at other stations (Table IV-23). Metal bioconcentrations by fishes was insignificant (Table IV-24).

Zinc, copper and arsenic concentrations were detected in a screech owl taken near Station 10b. Bioconcentration of these metals is assumed to be the result of feeding habits in croplands.

Two raccoon specimens were taken from the Station 10b area; both had appreciable zinc and copper concentrations in liver tissue. However, one raccoon had considerably higher levels of both metals, and, in addition, a concentration of 1.0 ug/l of mercury was detected in this specimen. This was the only mercury detected in biological specimens of the Study Area. The concentration detected in the raccoon was well below mammal and bird mercury concentrations reported from other sections of the United States (Dustman *et al.*, 1972). Concentrations of these metals may be attributed to the age, sex (3-3½ year old male) and feeding habits of the individual animal.

c. Metal Concentrations in the Ouachita River Basin.

(1) Station 1 (Bayou Bartholomew at Princeton Pike).

Concentration of iron in water at Station 1 was the highest value detected of all sampling stations (2.9 mg/l). Manganese was found at a concentration of 0.7 mg/l. Given the low-flow conditions, low pH and dissolved oxygen values and high free $CO_2$ readings during the sampling period (Appendix C), iron probably became soluble to ferrous bicarbonate and manganese to manganous bicarbonate. Barium and arsenic was also detected, but at concentrations suggesting natural origin (Table IV-21). Although lead, zinc and mercury were not detected in baseflows at Station 1 (Table IV-21), all three metals were detected in stormwater (Table IV-22) introduced with sediment (lead and zinc) and agricultural runoff (mercury).

No detectable mercury concentrations were noted in sediment (Table IV-23), fish tissues (Table IV-24) or mammal and bird liver tissues (Table IV-25) at this station. Environmental effects of mercury at this station appear to be insignificant. Except for a high zinc concentration in barred owl liver tissues (Table IV-25), biomagnification of other metals was not apparent.

(2) Station 2 (Interceptor Canal).

Iron, mercury and zinc were detected in water at Station 2 on July 18, 1974, (Table IV-21); no other metals were detected. Iron was noted at 2.7 mg/l, despite relatively high pH and D.O. levels and low $CO_2$ levels. The presence of zinc and mercury may have partly been due to dredging operations upstream from 34th Avenue. The presence of iron was probably due to the daily discharge from General Waterworks. Iron as ferric hydroxide can be deposited on fish eggs (McKee and Wolf, 1971). The role of ferric hydroxide in the suppression of benthic diversity of this station is undetermined.

Zinc and lead were detected in storm waters; mean concentrations were 0.14 and 0.08 mg/l, respectively (Table IV-22). In baseflows, Station 2 had the only detectable zinc concentration. Zinc and lead levels in green sunfish and golden shiners were lower at Station 2 than at Station 1 (Table IV-24) and metal biomagnification did not appear. Mud concentrations of lead and zinc at Station 2 were about the same as those at Station 1 (Table IV-23).

Arsenic was detected in mud at Station 2, but not in the water or the fish tissues. Barium was also detected in water at Station 2 (Table IV-21), but at a lower level than at Station 1.

(3) Station 3 (Bayou Bartholomew at Highway 15).

Low concentrations of mercury, manganese and iron were detected in water at Station 3 in baseflows (Table IV-21). Reducing conditions were not prevalent during the time of sampling, and, as a consequence, there were lower manganese and iron concentrations than at upstream sites. Mercury was detected in concentrations similar to those of Station 1 (Table IV-22). Fungicide use in agricultural croplands adjacent to Bayou Bartholomew was the probable source of mercury; however, no biomagnification of mercury was evident (Tables IV-24 and IV-25).

Zinc and lead were found in sediment samples in considerably higher concentrations at Station 3 than at stations 1 and 2 upstream (Table IV-23) and, lead concentrations in sediment were higher than at any other station. Several possible sources of lead are; 1) washoff of lead from the upstream bridge, 2) trash and garbage thrown off the bridge upstream from the sampling area, or 3) the area may act as a settling basin for many of the materials adsorbed onto silt particles entrained in upstream Jacksonian outcrop and alluvial terrace lands. Zinc and lead concentrations in water were low in baseflows and stormwater (Tables IV-21 and IV-22) and little biomagnification in fish, mammal and bird tissues was evident (Tables IV-24 and IV-25).

(4) Station 4 (Outlet Canal.

Water quality at Station 4 during both baseflow and storm events has been documented as the most degraded of any station (Section IV.B and Appendix C). Sediment analysis at this station (Table IV-23) supports these data, as zinc, copper, chromium and lead concentrations are some of the highest in the Study Area. All appear to reflect urban (industrial, commercial and residential) activites. Zinc and copper are known to react synergistically in water to produce more toxic effects to aquatic life than either metal by itself (McKee and Wolf, 1971). Chromium detected was probably in the chromic state, as the chromous ion is strongly oxidized to this form (McKee and Wolf, 1971).

Metals in baseflow and stormwater were insignificant when compared to sediment concentrations (Tables IV-21, IV-22, IV-23). Small amounts of arsenic and mercury were found and the mercury is probably the result of agricultural activities. Zinc and lead concentrations in stormwater were similar to those at other stations. No notable biomagnification of heavy metals was detected in either the golden shiner or orange-spotted sunfish at this station (Table IV-24).

(5) Station 5 (Bayou Bartholomew at Pinebergen).

Baseflow water quality data at Station 5 (Table IV-21) show the presence of iron, manganese and arsenic. Redox conditions at the time of sampling probably accounted for the concentrations of iron and manganese, and arsenic was probably transported to the station by sediment. Its source is either from pyrites or from insecticides used in agricultural areas. Arsenic was not found in the sediment or in any fish, mammal or bird tissues at Station 5 (Tables IV-23, IV-24 and IV-25).

Zinc and lead concentrations detected in stormwater were similar to those at other stations (Table IV-22). Mercury levels during runoff were similar to other stations in the Bartholomew System which receive agricultural runoff (stations 1, 3 and 4).

Copper, zinc and lead concentrations were significant in sediment samples (Table IV-23), with copper levels at 32 ug/g the highest noted value of any of the sampled stations. That copper was detected in sediment samples, but not in the water column, is not surprising because cupric ions introduced into natural waters at pH 7 or above will quickly precipitate as the hydroxide or as basic copper carbonate (McKee and Wolf, 1971). Synergism between copper

and zinc at Station 5 could have a direct effect upon aquatic invertebrate populations. Indeed, as water quality data from both baseflow and stormwater indicate no significant degradation of water quality as compared with upstream stations, and benthic diversities were somewhat lower than those at upstream sites, the metals adsorbed onto silt particles could limit the aquatic diversities of Station 5.

Copper was detected in one raccoon liver sample at Station 5; its source was likely from agricultural biocides. Lead and zinc concentrations were somewhat lower in samples of gizzard shad and warmouth and a screech owl liver (Tables IV-24 and IV-25), than at upstream stations. No other metal concentrations were detected in animal tissues from Station 5.

2. Pesticides and Herbicides.

Overland runoff and erosion are the principal means of biocide transport to the aquatic systems of the Study Area. The movement of pesticides, however, is complex and dependent upon biological and photo-degradation, chemical oxidation and hydrolysis, direct volatilization, migration into adjacent areas, translocation into plants, and adsorption onto airborne and soil particles (Teledyne Brown Engineering, 1972). Because of these complexities, no attempt has been made to quantify amounts of applied pesticides entering waterways of the Study Area. Figure IV-6 demonstrates an example of residual DDT levels in the physical environment and bioconcentration in plants and animals.

Toxicities of pesticides to aquatic life and higher vertebrates are largely unknown. However, pesticide limits for waters are recommended by the EPA and are presented in Tables IV-12 and IV-13.

a. Overview.

Inconsistencies between reported pesticide applications and detected concentrations existed in the Study Area. Despite the heavy application of a wide spectrum of biocides only, DDT concentrations in immature screech owls in or near agricultural areas were exceptionally high. DDT did not appear in the aquatic ecosystem. Detection problems may have existed in analysis of water, sediment and fishes, as a long-lived organochlorine compound such as DDT ultimately will wash into streams, bayous and lakes. Other compounds such as Dieldrin, Aldrin and PCB's were present in various waters and tissues but were not detected at significant levels. Effects of these compounds are probably most pronounced on aquatic invertebrates. However, the specific effects of biocides could not be established for the Study Area.

b. Agricultural Applications.

Cotton and soybeans are the primary cash crops grown in the Study Area, with the majority of acreage grown in the Deep Bayou and Arkansas River subbasins. In 1974, about 9,784 acres were planted with cotton. Pre-planting herbicides, namely Treflan and Cobex, were applied mostly prior to April 20. Karmex and Caparol (post-emergence herbicides) were generally applied at three-week intervals after cotton emergence. An average of 5.5 applications of toxaphene and methyl parathion were applied at intervals throughout the summer, with an

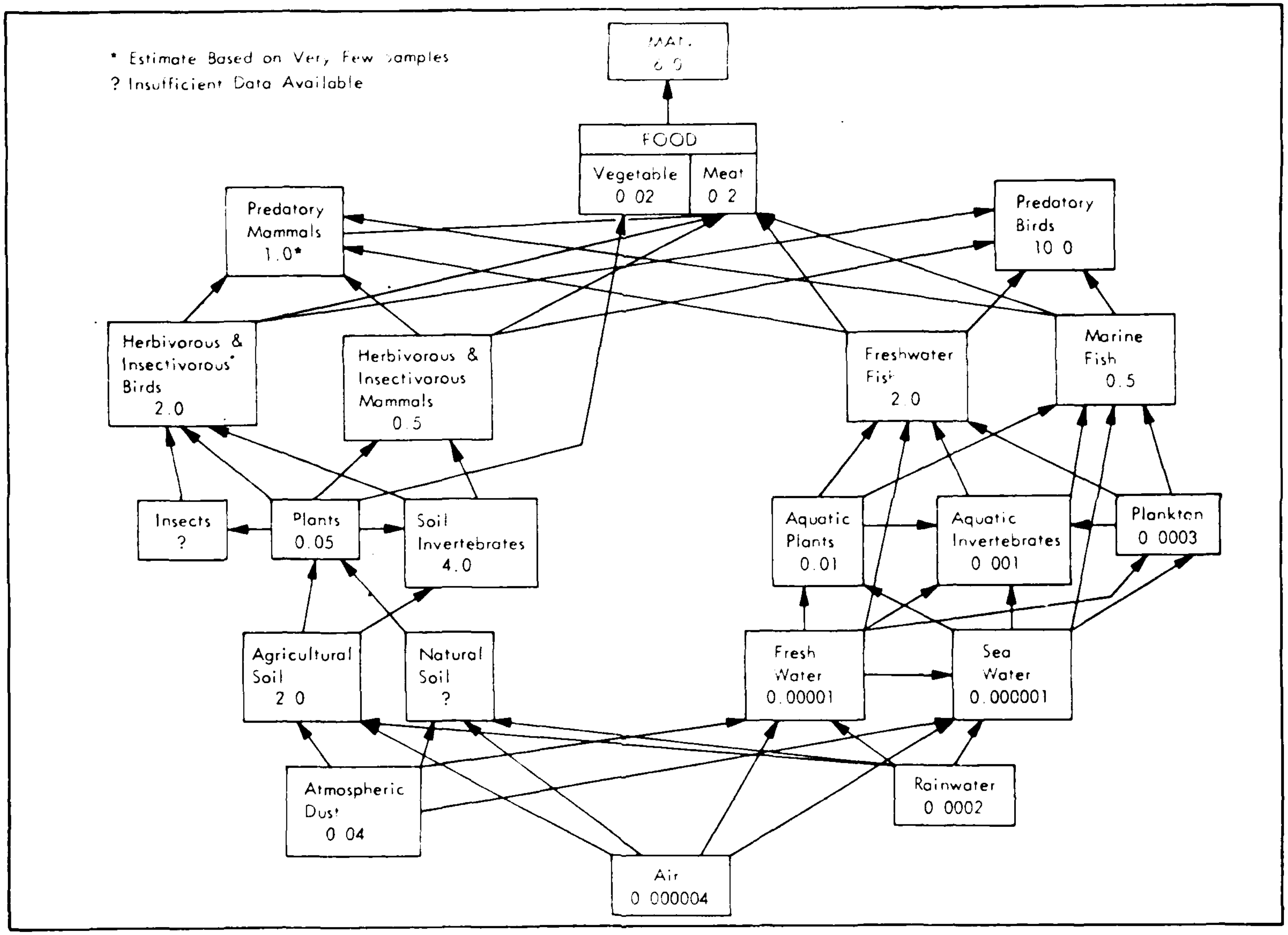



Figure IV- 6 Example of Pesticide Biomagnification (ppm DDT) in the Environment (after Edwards, 1970).

approximate dosage of 14,676 lbs. (7.34 tons) of Toxaphene and 9,784 lbs. (4.89 tons) of Methyl Parathion being applied to cotton. An organophosphate defoliant, (Folex) was applied during September and October with an approximate dosage of 12,817 lbs. (6.41 tons). Herbicide and pesticide application times, rates and total dosages are presented in Table IV-26.

Approximately 6,522 acres were utilized for soybean production in the Study Area in 1974. Treflan and Cobex were used as pre-emergence herbicides in April. In June and July, Dinoseb and Lorox, post-emergence herbicides, were applied to soybean fields at rates of 0.75-1.5 lbs/acre. Throughout the summer, Methyl Parathion and Toxaphene were applied to approximately five per cent of the total soybean acreage. Herbicide and pesticide application dates, rates of application and total dosages are presented in Table IV-27.

About 20 per cent of the Study Area's 7,578 acres of pastureland was treated with 2-4-D Amine at a rate of 1.0 lbs/acre, totaling 1,516 lbs. (0.76 tons).

Malathion, Toxaphene, Sevin, Chlordane and Diazinon are some of the more common insecticides utilized in local vegetable gardens. Malathion and Diazinon are organophosphates, Toxaphene and Chlordane are chlorinated hydrocarbons and Sevin is a carbamate.

Within the confines of the Study Area, about 6,310 acres of agricultural lands are drained by the Bartholomew System, 3,974 acres are drained by the Arkansas System and 7,891 acres are drained by the Deep Bayou System.

The major proportion of pesticide applications occurs in the Deep Bayou, Arkansas, Imbeau, Lower Bartholomew, Outlet, Boggv and Belmont sub-basins, as almost all of the cotton and soybean production is located in these areas. In the sub-basins of Imbeau and Outlet, significant quantities of biocides enter Bayou Imbeau and in the absence of flow it serves as a major collector and settling basin. It is estimated that Bayou Imbeau received approximately 80 per cent of the agricultural runoff from total cotton-soybean acreage of these sub-basins. Bayou Imbeau discharges to Outlet Canal and Bayou Bartholomew only during and following major storm events. The remainder of agricultural runoff generated in the Imbeau and Outlet sub-basins drains into either Outlet Canal or Bayou Bartholomew.

The Belmont, Pitts Drain and Lamont sub-basins account for only 134 acres of agricultural croplands or two per cent of the total croplands drained by the Bartholomew System. Outlet Canal receives the agricultural runoff from these areas.

The Lower Bartholomew and Bartholomew at Pinebergen sub-basins receive the runoff from 2,752 acres of lands dominated by soybean-cotton activity. This accounts for 44 per cent of the total agricultural lands within the Ouachita System. Poorly drained areas within these sub-basins probably receive a significant amount of agricultural runoff; consequently, some assimilation of pesticide-laden soil particles could be expected. Wetlands interspersed among agricultural fields probably serve as settling basins for silt and adsorbed biocides and nutrients during low-flow conditions and after periods of low intensity and short-duration storms.

TABLE IV-26
Application of Herbicides and Pesticides to Cotton

| EVENT | TIME PERIOD | APPLICATIONS TYPE | NO. | RATE LB./AC. | APPLICATION SIZE TOTAL LBS. | TOTAL TONS |
|---|---|---|---|---|---|---|
| Pre-planting Herbicides | Prior to April 20-May 20 | Treflan | 1 | 0.75 | 7,338 | 3.67 |
| Pre-planting Herbicides | Prior to April 20-May 20 | Cobex | 1 | 0.50 | 4,892 | 2.45 |
| Post-emergence Herbicides | 3 weeks after emergence | Karmex | 1 | 0.93 | 9,099 | 4.55 |
| Post-emergence Herbicides | 3 weeks after emergence | Caparol | 1 | 2.0 | 19,568 | 9.78 |
| Post-emergence Herbicides | 3 week intervals | Karmex | 2 | 0.4 | 7,828 | 3.92 |
| Post-emergence Herbicides | 3 week intervals | Caparol | 2 | 0.8 | 15,654 | 7.82 |
| Insecticide Applications | Throughout summer | Toxaphene | 5.5 | 1.5 | 14,676 | 7.34 |
| Insecticide Applications | Throughout summer | Methyl Parathion | 5.5 | 1.0 | 9,784 | 4.89 |
| Defoliant Application | September-October | Folex | 1 | 1.31 | 12,817 | 6.41 |

Source: Jefferson County Cooperative Extension Service, pers. comm.

TABLE IV-27
Application of Herbicides and Pesticides to Soybeans

| EVENT | TIME PERIOD | APPLICATIONS TYPE | APPLICATIONS NO. | RATE LB./AC. | APPLICATION SIZE TOTAL LBS. | APPLICATION SIZE TOTAL TONS |
|---|---|---|---|---|---|---|
| Pre-emergence Herbicides | April | Treflan | 1 | 0.75 | 4,892 | 2.45 |
| Pre-emergence Herbicides | April | Cobex | 1 | 0.50 | 3,261 | 1.63 |
| Post-emergence Herbicides | June-July | Dinoseb | 1 | 1.5 | 9,783 | 4.84 |
| Post-emergence Herbicides | June-July | Dinoseb | 1 | 1.0 | 6,522 | 3.26 |
| Post-emergence Herbicides | June-July | Lorox | 1 | 0.75 | 4,892 | 2.45 |
| Insecticide Applications | Summer | Toxaphene | - | 2.0 | 652 | 0.33 |
| Insecticide Applications | Summer | Methyl Parathion | - | 0.25 | 82 | 0.04 |

Source: Jefferson County Cooperative Extension Service, pers. comm.

c. Pesticide Analysis and Discussion.

Analyses of water, mud and tissues of whole herbivorous and carnivorous fishes were made for pesticides at eight stations (1, 2, 3, 4, 5, 7, 9a and 10b), with raccoon liver and barred owl and screech owl liver analyses made at all stations but 2 and 4. Age, sex and weight of birds and mammals are presented in Table IV-28. Pesticide concentrations detected in water, mud, fish and bird and mammal tissues are presented in Tables IV-29, IV-30 and IV-31, respectively. Aldrin was the only pesticide detected in water samples. Dieldrin, DDT, and polychlorinated biphenyls (PCB's) were detected in bird and mammal tissues and only PCB's were detected in fish tissues. Pesticides were not detected in any of the sediment samples. For comparative purposes, the results of 1973 pesticide analyses in the waters of the Arkansas River by the Department of Pollution Control and Ecology is presented in Table IV-32. Aldrin was detected at almost all stations, with the high values recorded for the urban stations (2 and 4). The presence of Aldrin in natural waters is somewhat surprising, because it has not been used on cotton or soybeans for five to six years in Jefferson County (Jefferson County Cooperative Extension Service, pers. comm.). Aldrin can convert by photoisomerization to photoaldrin, a compound 11 times more toxic than Aldrin and Aldrin has been noted to undergo epoxidation to Dieldrin in river water (Teledyne Brown Engineering, 1972). Although the concentration of Aldrin in the Study Area is well below known toxic levels, the effects of Aldrin under various conditions is presented in Table IV-33.

Polychlorinated biphenyls (PCB's) were detected in all herbivorous and carnivorous fishes and in raccoon liver samples in the Pine Bluff area. Concentrations ranged from 0.50 ppm PCB's in a 3-3½ year old male raccoon taken near Station 10b to 0.02 ppm PCB's in a 1½-2 year old female raccoon obtained in close proximity to Station 3 (Table IV-31). Concentrations of PCB's in shad ranged from 0.70 ppm at Station 3 to 0.40 ppm at Station 5. Golden shiners had PCB levels from 0.60 ppm at Station 7 to 0.05 ppm at Station 9a. PCB concentrations in carnivorous fishes ranged from 2.0 ppm in green sunfish at Station 2 to 0.06 ppm in green sunfish at Station 1 (Table IV-30).

Polychlorinated biphenyls have become ubiquitous in the world ecosystem and in quantities similar to those of DDE. PCB's are used almost exclusively in industry and appear to be more persistent than DDT (Muirhead-Thomson, 1971). Possible PCB sources in the Study Area are plastics, wire insulation, epoxy-resin paints and a host of other materials. Toxicities of PCB's are similar to those of DDE and other chlorinated hydrocarbons and they effect reproduction and other physiological processes following injestion. Like the chlorinated hydrocarbons, PCB's are stable and long-lived.

Although PCB concentrations in Study Area fishes were in a range described for other studies (Jensen et al., 1969), no pronounced bioconcentration of PCB's was detected in raccoons or owls and the concentrations were below toxic limits. PCB effects on benthic populations in the Study Area are undetermined. At present, in the absence of detectable quantities in sediment, their effect is assumed to be minimal.

Three raccoons and six owls in the Study Area had varying concentrations of Dieldrin and DDT (Table IV-31). Neither of these chlorinated hydrocarbon

TABLE IV-28
Age, Sex and Weight of Test Specimens*

I. RACCOONS

| Station No. | Age (Yrs.) | Sex | Weight (Kg.) |
|---|---|---|---|
| 1 | 3 | M | 1.682 |
| 3 | 1½-2 | F | 1.318 |
| 5 | 2 | M | 1.727 |
| 7 | 1½-2 | F | 2.367 |
| 9a | 2-2½ | F | 2.500 |
| 10b | 3-3½ | M | 3.636 |

II. OWLS

| Station No. | Owl Species | Age* | Weight (Kg.) |
|---|---|---|---|
| 1 | Barred | Ad | 0.620 |
| 3 | Barred | Ad | 0.335 |
| 5 | Screech | Im | 0.115 |
| 7 | Screech | Ad | 0.150 |
| 9a | Screech | Im | 0.120 |
| 10b | Screech | Ad | 0.135 |

*Sex not determined for owls;
Ad = adult, Im = immature

TABLE IV-29
Pesticide Levels in Study Area Water (W) and Sediment (S)

| PESTICIDE | STATION NUMBER AND CONCENTRATION (WATER, ug/l; MUD, ug/g) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 7 | | 9a | | 10b | |
| | W | S | W | S | W | S | W | S | W | S | W | S | W | S | W | S |
| Lindane | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| DDE | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Endrin | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| DDL | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Chlordane | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Heptachlor | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| DDT | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Methoxychlor | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Heptachlor epoxide | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Dieldrin | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Endosulfan | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Methyl parathion | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Toxaphene | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |
| Aldrin | 1.0 | <.01 | 1.2 | <.01 | 1.0 | <.01 | 1.3 | <.01 | <1 | <.01 | 1.2 | <.01 | <1 | <.01 | 1.0 | <.01 |
| PCB | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 | <1 | <.01 |

TABLE IV-30
PCB Levels in Fishes at Eight Stations in the Pine Bluff Area

| SPECIES | STATION NUMBER AND CONCENTRATION IN PPM 1 | 2 | 3 | 4 | 5 | 7 | 9a | 10b |
|---|---|---|---|---|---|---|---|---|
| Gizzard Shad | - | - | 0.70 | - | 0.40 | - | - | 0.50 |
| Golden Shiner | 0.20 | 0.10 | - | 0.40 | - | 0.60 | 0.05 | - |
| Green Sunfish | 0.06 | 2.00 | - | - | - | 0.50 | - | - |
| Bluegill | - | - | 0.04 | - | - | - | 0.40 | - |
| Longear Sunfish | - | - | - | - | - | - | - | 0.20 |
| Orangespotted Sunfish | - | - | - | 1.00 | - | - | - | - |
| Warmouth | - | - | - | - | 0.30 | - | - | - |

TABLE IV-31
Pesticide Levels in Study Area Mammals (M) and Birds (B)

| PESTICIDE | STATION NUMBER AND CONCENTRATION (ug/g) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 3 | | 5 | | 7 | | 9a | | 10b | |
| | M | B | M | B | M | B | M | B | M | B | M | B |
| Lindane | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| DDE | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Endrin | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| DDD | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Chlordane | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Heptachlor | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| DDT | < .01 | 2.40 | < .01 | 4.80 | 0.24 | 181.00 | 0.20 | 8.50 | 0.11 | 124.70 | < .01 | 50.50 |
| *Methoxychlor* | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Heptachlor epoxide | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Dieldrin | < .01 | 0.84 | < .01 | 0.08 | 0.06 | 0.06 | 0.05 | 0.14 | 0.07 | 0.06 | < .01 | 0.17 |
| Endosulfan | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Methyl parathion | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Toxaphene | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| Aldrin | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 | < .01 |
| PCB | 0.50 | < .01 | 0.02 | < .01 | 0.37 | < .01 | 0.40 | < .01 | 0.41 | < .01 | 0.05 | < .01 |

TABLE IV-32
Pesticide Monitoring Results in the Arkansas River
September, 1973

| PARAMETER (mg/l) | RIVER MILE 82.9 | 75.6 | 63.0 |
|---|---|---|---|
| Lindane | < 1 | < 2 | < 3 |
| Heptachlor | < 3 | < 6 | < 5 |
| Aldrin | < 1 | < 1 | < 5 |
| Heptachlor epoxide | < 2 | < 4 | < 10 |
| DDE | < 1 | < 2 | < 10 |
| Endosulfan | < 1 | < 3 | < 6 |
| Dieldrin | < 2 | < 4 | < 10 |
| Endrin | < 10 | < 10 | < 30 |
| DDD | < 10 | < 10 | < 20 |
| DDT | < 10 | < 20 | < 30 |
| Methoxychlor | < 30 | < 50 | < 100 |
| Toxaphene | < 70 | < 100 | < 800 |
| Methyl parathion | < 10 | < 20 | 76 |

Source: Arkansas Department of Pollution Control and Ecology, pers. comm.

TABLE IV-33
Toxicities of Aldrin to Aquatic Organisms

A. FISHES

| CONCENTRATION OF ALDRIN mg/l | TEMPERATURE °C | TYPE OF* WATER | TYPE OF FISH | RESULT |
|---|---|---|---|---|
| 0.013 | 25 | (3) | Bluegill | 96 hr. $TL_m$ |
| 0.028 | 25 | (2) | Fathead | 96 hr. $TL_m$ |
| 0.028 | 25 | (3) | Goldfish | 96 hr. $TL_m$ |
| 0.033 | 25 | (3) | Fathead | 96 hr. $TL_m$ |
| 0.033 | 25 | (3) | Guppies | 96 hr. $TL_m$ |
| 0.05 | 20-22 | (-) | Guppies | 3 hrs.-Abnormal behavior<br>48 hrs.-Death |
| 5.0 | 13 | (1) | Rainbow Trout | No effect in 24 hours |
| 5.0 | 13 | (1) | Bluegill | No effect in 24 hours |

* (1) Water pH 7.5-8.2; D.O. 8.6-13.7 mg/l; free $CO_2$ 5.0-9.0 mg/l.
(2) Hardwater, pH 8.2; D.O. 8.0 mg/l; alkalinity 360 mg/l; hardness 400 mg/l.
(3) Softwater, pH 7.4; D.O. 8.0 mg/l; alkalinity 18 mg/l; hardness 20 mg/l.

B. OTHER AQUATIC INVERTEBRATES

| CONCENTRATION OF ALDRIN mg/l | TEMPERATURE °C | ORGANISM | RESULT |
|---|---|---|---|
| 0.012 | - | *Chironomus* sp. | 8 hr. $TL_{50}$ |
| 4.8 | - | Lymnaeid Snails | Death in 24 hours |
| 0.029 | 20 | *Daphnia magna* | Immobilization at 50 hours |

Source: Teledyne Brown Engineering, 1972.

compounds was detected in the remaining three raccoons, herbivorous and carnivorous fishes or in any of the water and mud samples. Whether this absence was due to detection problems is unknown.

Dieldrin concentrations in raccoons ranged from < 0.01 ug/g at stations 1, 3 and 10b to 0.07 ug/g at Station 9a (Table IV-31). Concentration of this compound in owls ranged from 0.06 ug/g at stations 5 and 9a to 0.84 ug/g at Station 1 (Table IV-31). Dieldrin concentrations did not approach toxic levels reported by Belisle et al. (1972) in bald eagles. As Dieldrin was detected only in terrestrial animals, it is presumed that their concentrations are due to terrestrial, not aquatic, feeding.

Dieldrin is used primarily for termite control in the Study Area; extent of usage in terms of pounds applied is unknown. It has some limited usage for vegetable and fruit crop nuisance insect control.

Properties of Dieldrin are similar to Aldrin. In water, Dieldrin can be photoisomerized to Photodieldrin, a compound 11 times more toxic to aquatic vertebrates than Dieldrin (Teledyne Brown Engineering, 1972). Dieldrin is extremely persistent in both soils and water.

DDT was detected in varying concentrations in three raccoon and six owl liver samples. In raccoons, detectable concentrations ranged from < 0.01 ug/g at stations 1, 3 and 10b to 0.24 ug/g at Station 5 (Table IV-31). In owls, concentrations ranged from 2.40 ug/g at Station 1 to 181.00 ug/g at Station 5 (Table IV-31). DDT concentrations in three owls far exceeded DDT concentrations in various waterfowl and shorebirds noted by Fruh (1971; Table IV-34). Screech owls had higher concentrations of DDT in liver tissues than barred owls (Tables IV-28, IV-31). Screech owl comparisons show a significantly higher DDT concentration in the immature specimens as opposed to adults (Tables IV-28, IV-31). Additionally, owls collected in agricultural areas or in close proximity to such areas had higher DDT concentrations than those owls collected in non-agricultural areas.

DDT usage in the Study Area is reported at present to be minimal, compared to past usage (Jefferson County Cooperative Extension Service, pers. comm.). In view of the owl liver DDT concentrations, notably in agricultural areas, this seems questionable and possibly a considerable amount of non-reported DDT usage occurs in the Study Area.

DDT and its metabolites, DDD and DDE, have been shown to cause eggshell thinning in birds such as bald eagles and brown pelicans. DDT can impair osmoregulation and active membrane support; additionally, DDT and its metabolites induce mixed function oxidose enzymes which function in metabolizing steroid hormones such as estrogen and testosterone (Teledyne Brown Engineering, 1972). Motor and sensory systems may be impaired by sublethal concentrations of chlorinated hydrocarbons such as DDT (Teledyne Brown Engineering, 1972). DDT is very stable in soil, decomposing at a rate of about five per cent per year depending on soil type (McKee and Wolf, 1971). Apparently, DDT is stored to a point of equilibrium in vertebrate tissues; in man the equilibrium concentration was reported to be 234 - 340 mg/kg (Teledyne Brown Engineering, 1972).

TABLE IV-34
DDT Residues in Whole Organisms
(Long Island, New York)

| SAMPLE | | DDT RESIDUES (mg/l) |
|---|---|---|
| Cladophora gracilus | Green Alga | 0.83 |
| Unknown Species | Crickets | 0.23 |
| Nassarius obsoletus | Mud Snail | 0.26 |
| Gasterosteus aculeatus | Threespine Stickleback | 0.26 |
| Anguilla rostrata | American Eel | 0.28 |
| Anas rubripes | Black Duck | 1.07 |
| Esox niger | Chain Pickerel | 1.33 |
| Butroides virescens | Green Heron (a) | 3.51 |
| B. virescens | Green Heron (b) | 3.57 |
| Pandion haliaetus | Osprey | 13.8 |
| Mergus serrator | Red-breasted Merganser | 22.8 |
| Phalacrocorox avritus | Double-breasted Cormorant | 26.4 |

Source: Fruh, 1971.

DDT concentrations noted in the Study Area appear to result from terrestrial feeding habits of test organisms. Either DDT remains intact in the soil or it is still being applied in significant amounts. Apparently, screech owls, notably immature individuals, feed extensively in agricultural areas upon contaminated insects and rodents. The equilibrium DDT concentration for screech owls is not known, nor or the effects of the detected concentrations. Snyder et al. (1973) suggested that several hawks of the genus Accipiter had experienced population declines due to concentrations of DDE, a DDT metabolite, in their tissues. Additionally, they noted disturbed parental behavior in nests which contained eggs contaminated with DDE. Screech owl populations could be affected by DDT bioconcentration in the Study Area in similar ways. DDT appears to be widespread in the terrestrial Study Area ecosystem, notably so in agricultural areas. Other predatory birds in the Study Area probably also contain high DDT levels.

## D. GROUND WATER QUALITY.

Based on Klein et al. (1950), Broom and Reed (1973) and Hosman et al. (1968), the following sections treat the ground water quality of the three principal aquifers in Jefferson County and the Study Area: the Sparta Sands, the combined Jackson-Cockfield (undifferentiated Eocene of earlier authors) and the Quaternary deposits. In consideration of the large increases in withdrawals and subsequent changes in the ground flow that occurred since the major sampling period in 1949 (Klein et al., 1950), the data and conclusions must be considered as only approximations of extent quality. (See also Section II.D.3 and 4.)

### 1. The Sparta Sand Aquifer.

Water in the Sparta Sand is soft and only moderately mineralized. Data (Table IV-35) indicate that the concentrations of all constituents except sodium and bicarbonate are low. Iron occurs in levels that necessitate treatment throughout the Study Area, but exceptionally high levels occur only near the western outcrop areas. The dissolved solids content of the water increases as the water moves south-eastward or downdip; however, calcium, magnesium and iron decrease with downdip movement. With some treatment such as iron removal, water of the Sparta Sand is of good quality and suitable for all uses.(Table IV-36)

### 2. The Jackson-Cockfield Aquifer.

Water from the Jackson-Cockfield System (undifferentiated Eocene) is both moderately hard and mineralized. Table IV-37 indicates that levels of silica, sodium bicarbonate and sulfate are high. The elevated sulfate comes from the Jackson Group which in Jefferson County is continuous with the underlying Cockfield. The total dissolved solids increase in sodium and bicarbonate with the southeastward or downdip movement of water. With this same movement, the concentrations of calcium, magnesium and sulfate decrease. Water of the Jackson-Cockfield aquifer is of fair to good quality and suitable for most uses. Softening, however, would be recommended before municipal use.

### 3. The Quaternary Aquifer.

The ground water of the Pleistocene Terrace deposits differ significantly from the ground water of the eastern Holocene Alluvium (Table IV-38). Terrace water is typically a sodium bicarbonate type rather than

TABLE IV-35
Ground Water Quality of the Sparta Sand Aquifer

| PARAMETERS* | MAXIMUM | MINIMUM | MEAN |
|---|---|---|---|
| Temperature (°F) | 79.0 | 71.0 | 75.3 |
| pH | 8.4 | 6.6 | 7.6 |
| Dissolved Solids | 138.0 | 60.0 | 89.9 |
| Specific Conductance (micromhos/cm) | 207.0 | 86.7 | 133.5 |
| Calcium | 11.0 | 4.9 | 7.1 |
| Magnesium | 3.3 | 1.6 | 2.1 |
| Sodium | 35.0 | 6.6 | 16.1 |
| Potassium | 7.2 | 1.9 | 3.9 |
| Iron | 14.0 | 0.3 | 2.3 |
| Silica | 16.0 | 12.0 | 14.5 |
| Aluminum | 2.5 | 0 | 0.4 |
| Bicarbonate | 127.0 | 41.0 | 71.0 |
| Sulfate | 10.0 | 0.6 | 5.0 |
| Chloride | 6.2 | 2.5 | 3.8 |
| Nitrate | 0.7 | 0 | 0.2 |
| Fluoride | 0.4 | 0 | 0.2 |
| Total Hardness | 41.0 | 19.0 | 26.5 |
| Non-carbonate Hardness | 0 | 0 | 0 |
| Per Cent Sodium | 73.0 | 31.0 | 50.9 |

* Data in milligrams/liter unless noted otherwise.

Source: Klein et al., 1950.

TABLE IV-36
Treated and Untreated Ground Water Quality of the Sparta Sand Aquifer*

| PARAMETERS** | UNTREATED | TREATED |
|---|---|---|
| Color (PCU) | 50.0 | 5.0 |
| Odor | 0 | 0 |
| Turbidity (JTU) | 7.0 | 0.5 |
| Sediment | 0 | 0 |
| pH | 7.0 | 7.0 |
| Phenophthalein Alkalinity | 0 | 0 |
| Methyl Orange Alkalinity | 51.0 | 50.0 |
| Total Solids | 126.5 | 116.0 |
| Total Hardness | 23.0 | 25.0 |
| Carbonate | 23.0 | 25.0 |
| Non-carbonate | 0 | 0 |
| Chlorides | 2.8 | 6.5 |
| Sodium Chloride | 16.0 | 10.8 |
| Sulphate | 2.5 | 1.0 |
| Calcium | 5.8 | 5.6 |
| Magnesium | 6.0 | 6.6 |
| Iron | 1.8 | 0.12 |
| Manganese | 0.21 | 0.019 |
| Fluoride | 0.2 | 0.2 |
| Chromium | < 0.003 | < 0.003 |
| Copper | < 0.05 | < 0.05 |
| Aluminum | < 0.2 | < 0.2 |
| Lead | < 0.01 | < 0.01 |
| Sodium | 20.5 | 20.0 |
| Nitrate | 0.48 | 0.32 |
| Nitrite | < 0.01 | < 0.01 |
| Arsenic | < 0.01 | < 0.01 |
| Mercury | < 0.001 | < 0.001 |
| Nickel | 0.006 | < 0.005 |
| Cadmium | < 0.005 | < 0.005 |
| Zinc | < 0.005 | < 0.005 |
| Silver | < 0.005 | < 0.005 |

*Monitored by the General Waterwords Corporation, February, 1973. Average values are for Plant No. 1

**Data in milligrams/liter unless otherwise noted.

Source: Arkansas State Department of Health, 1973.

TABLE IV-37
Ground Water Quality of the Jackson-Cockfield Aquifer
(Undifferentiated Eocene)

| PARAMETERS* | MAXIMUM | MINIMUM | MEAN |
|---|---|---|---|
| Temperature ($^{o}F$) | 69.0 | 60.0 | 64.3 |
| pH | 8.6 | 5.8 | 7.7 |
| Dissolved Solids | 731.0 | 83.0 | 383.4 |
| Specific Conductance (micromhos/cm) | 1,125.0 | 72.6 | 564.8 |
| Calcium | 99.0 | 1.3 | 21.0 |
| Magnesium | 24.0 | 0.2 | 5.2 |
| Sodium | 215.0 | 11.0 | 94.9 |
| Potassium | 7.3 | 0.1 | 2.5 |
| Iron | 10.0 | 0.1 | 2.5 |
| Silica | 100.0 | 2.0 | 30.8 |
| Aluminum | 2.2 | 0.2 | 1.0 |
| Bicarbonate | 456.0 | 12.0 | 215.8 |
| Sulfate | 243.0 | 3.5 | 88.6 |
| Chloride | 56.0 | 7.5 | 17.5 |
| Nitrate | 2.6 | 0 | 0.6 |
| Fluoride | 0.3 | 0 | 0.1 |
| Total Hardness | 346.0 | 4.0 | 73.8 |
| Non-carbonate Hardness | 54.0 | 0 | 5.3 |
| Per Cent Sodium | 93.0 | 27.0 | 72.6 |

* Data in milligrams/liter unless noted otherwise.

Source: Klein *et al*., 1950.

TABLE IV-38
Ground Water Quality of the Quaternary Aquifer

| PARAMETERS* | MAXIMUM | MINIMUM | MEAN |
|---|---|---|---|
| Temperature (°F) | 66.0 | 60.0 | 63.5 |
| pH | 8.0 | 4.8 | 7.2 |
| Dissolved Solids | 2,360.0 | 195.0 | 477.8 |
| Specific Conductance (micromhos/cm) | 3,120.0 | 72.6 | 738.9 |
| Calcium | 196.0 | 8.0 | 83.1 |
| Magnesium | 83.0 | 2.3 | 22.8 |
| Sodium | 393.0 | 8.3 | 47.2 |
| Potassium | 6.6 | 0.2 | 1.8 |
| Iron | 28.0 | 0.3 | 7.2 |
| Silica | 60.0 | 11.0 | 26.7 |
| Aluminum | 19.0 | 0 | 1.6 |
| Bicarbonate | 602.0 | 2.0 | 344.1 |
| Sulfate | 1,260.0 | 1.0 | 68.1 |
| Chloride | 280.0 | 3.8 | 42.7 |
| Nitrate | 58.0 | 0 | 3.5 |
| Fluoride | 0.6 | 0 | 0.2 |
| Total Hardness | 831.0 | 29.0 | 301.0 |
| Non-carbonate Hardness | 829.0 | 0 | 32.8 |
| Per Cent Sodium | 75.0 | 6.0 | 23.3 |

*Data in milligrams/liter unless otherwise noted.

Source: Klein et al., 1950.

calcium bicarbonate and is appreciably lower in dissolved solids, hardness and iron. The higher altitude of the terrace allows for a deeper water table and a steeper hydraulic gradient. Both of the physical qualities favor the dilution of recharge and a faster rate of water movement to discharge points. The terrace waters are also comparatively soft with both calcium and magnesium of the overlying soils removed by the rapidly circulating water.

Eastward on the Alluvium and west of the Arkansas River, the dissolved solids and specific conductivity increase concomitant with increases in both calcium and bicarbonate. These ions increase through downward percolation and dissolution of carbonates in the overlying soils. Moreover, the elevated water table allows carbon dioxide from plant root respiration and decay of organic matter to become an important component of the downward moving waters and participate in carbonate dissolution. The eastward increase in iron levels may stem from the percolation of water through iron bearing soils and the release of soluble iron by chemical reduction in the organically rich soil and sediment.

Historically, before the establishment of navigation pools in 1968, the Arkansas River substantially aided the preservation of water quality during recharge stages (Broom and Reed, 1973). The current effect on water quality by the river is unknown.

4. Summary of Chemical Analysis of Aquifers.

a. Dissolved Solids.

Dissolved solids are often a major determiner of water use. The U.S. Public Health Service (1961) recommends that water containing over 500 mg/l of dissolved solids not be used for potable water if less mineralized water is available. A concentration of 1,000 mg/l is considered an upper limit for most industrial uses and over 1,500, unsuitable for irrigation.

The dissolved solids of the Study Area aquifers range from 60 mg/l in wells of the Sparta Sand to 2,360 mg/l from a single well in the Quaternary Aquifer (Tables IV-35 and IV-38). Although there is a distinct gradient of increasing dissolved solids from the Sparta to the Quaternary deposits, the majority of the wells (about 88 per cent) yield water with less than 500 mg/l dissolved solids and fall within acceptable limits.

The mean level of dissolved solids for waters of the Sparta Sand is about 90 mg/l (Tables IV-35 and IV-36). Low values occur in the western recharge areas reflecting dilution and higher values are found eastward concomitant with increasing levels of sodium and bicarbonate. The effect of the recent cone of depressions and attendant reversals of flow on local levels of dissolved solids is not known. However, comparison of General Waterworks data from 1949 and 1973 indicates only a small increase in dissolved solids (about 20 mg/l).

The Jackson-Cockfield aquifer is moderately mineralized with dissolved solids averaging 383 mg/l and with the dissolved solids of most wells above 300 mg/l (Table IV-37).

The Quaternary wells are highly variable with dissolved solids ranging from 195 mg/l to over 2,000 mg/l (Table IV-38). The mode lies between 350 and 450 mg/l. The aquifer, however, in practically all areas draining to Bayou Bartholomew yields water with less than 500 mg/l and with considerable reductions westward on the terrace deposits. Moreover, dissolved solids are also reduced in wells bordering the Arkansas River.

b. Calcium and Magnesium.

Calcium and magnesium levels in aquifer water are present through contact with either limestone or dolomite, respectively. Both calcium and magnesium are major contributors to the hardness of water.

The Sparta Sand aquifer yields water with very low levels of both calcium and magnesium; means of 7.1 and 21. mg/l, respectively (Tables IV-35 and IV-36). Levels of calcium and magnesium are highest in the western areas near the recharge area and decrease with the movement of water downdip.

In the Jackson-Cockfield aquifer, calcium and magnesium average 21.0 mg/l and 5.2 mg/l, respectively, and fall well within prescribed limitations (Table IV-37). Where the aquifer is recharged from the overlying Quaternary deposits in the west, calcium levels are elevated. As in the Sparta Sand, both calcium and magnesium decrease as water moves southeastward, downdip.

Waters of the Quaternary aquifer yield calcium and magnesium levels significantly greater than those of the underlying aquifers (means of 83.1 mg/l and 22.8 mg/l, respectively; Table IV-38). The higher levels are particularly pronounced in the Holocene Alluvium where calcareous soils are attacked by downward percolating waters.

c. Sodium and Potassium.

Elevated levels of sodium and potassium seldom have an effect on the suitability of water for most uses. However, when sodium and potassium salts make up the majority of the mineral content, the water may not be satisfactory for irrigation. In Jefferson County, sodium ranged from 6.6 to 393 mg/l and was usually less than 150 mg/l; potassium ranged from 0.1 to 8.8 mg/l (Tables IV-35 and IV-38). In all aquifers, levels of potassium were low. Sodium, however, increased from an average value of 16.1 mg/l in the Sparta Sand aquifer to 94.9 mg/l in the Quaternary aquifer. In the Sparta and Jackson-Cockfield aquifers, sodium and bicarbonate are responsible for much of the southeastward increase in dissolved solids.

The Quaternary aquifer system has sporadic increases in sodium levels, principally in the Holocene Alluvium to the east. These may result from elevated water tables and their interactions with surface material.

d. Iron.

Iron typically enters ground water through the reduction of oxides by downward percolating water. Iron in water is commonly incompatable with many industrial uses and objectionable in public supplies. On exposure to air, such as at discharge points, soluble iron is oxidized and contributes to surface water turbidity.

In Jefferson County, iron levels range from 0.03 to 28.0 mg/l, and the majority of wells do not meet the U.S. Public Health (1961) public water supply criteria of 0.3 mg/l (Tables IV-35 and IV-38). Iron values for the Sparta Sand, Jackson-Cockfield and Quaternary aquifers are irregularly distributed over the county, but generally the higher values occur in the western sectors near areas of outcrop.

e. Silica.

Silica as silica dioxide enters the ground water from the dissolution of rock material. Levels of silica are seldom high and seldom interfere with water use with the exception of the formation of boiler scale. In Jefferson County, silica ranges from 2.0 to 100.0 mg/l with the highest levels in the Jackson-Cockfield and Quaternary aquifers (means of 26.7 and 30.8 mg/l, respectively; Tables IV-37 and IV-38).

f. Bicarbonate.

Bicarbonate is the principal anion of the ground water in each aquifer. In both the Sparta Sand and Jackson-Cockfield aquifers, bicarbonate levels increase downdip, and along with sodium are responsible for increased levels of dissolved solids. In the Quaternary aquifer, bicarbonate increases eastward in the Holocene Alluvium. In Jefferson County, bicarbonate levels ranged from 2.0 to 602 mg/l (Tables IV-35 and IV-38). Few samples from the Sparta Sand contained more than 100 mg/l bicarbonate and few from the Jackson-Cockfield were over 300 mg/l. In the Quaternary, many wells had bicarbonate levels over 400 mg/l.

g. Sulfate.

Sulfate levels for public supply should not exceed 250 mg/l (U.S. Public Health Service, 1961). In the Sparta Sand aquifer, the primary supplier of potable water, the sulfate level is low (means of 5.0 mg/l; Tables IV-35 and IV-36). In the Jackson-Cockfield and Quaternary aquifers, however, high levels of sulfates are common, particularly in the lower Jackson-Cockfield (means of 88.6 and 68.1 mg/l, respectively; Tables IV-37 and IV-38). Sulfate levels decrease with ground water flow southeastward away from the areas of recharge.

h. Chloride.

Chloride is one of the principal anions of calcium, magnesium, sodium and potassium and typically varies directly with dissolved solids. Levels of chloride over 500 mg/l will affect many industrial uses and 250 mg/l is the upper limit set for drinking waters (U.S. Public Health Service, 1961). The range in Jefferson County is from 2.5 to 280.0 mg/l. However, in each aquifer the average value of chloride is less than 50 mg/l (Tables IV-35 and IV-38). Locally, chlorides will vary with variations in transmissivity and in the Quaternary aquifer, with evapotranspiration rates and interaction with surface soils.

i. Nitrate.

Nitrate levels are generally low; however, a few Quaternary aquifer wells have levels of above 5 mg/l. This may be the result of local contamination by sewage or other organic matter.

j. Hardness.

Hardness is principally a reflection of calcium, magnesium and iron levels. Hardness classification of the aquifers include: Sparta Sand, mean hardness 26.5 mg/l (soft); Jackson-Cockfield, 73.8 mg/l (moderately hard); Quaternary, 301.0 mg/l (very hard).

In the Quaternary, the water draining to Bayou Bartholomew from the west is typically less than 100 mg/l hardness. East of the Alluvial Terrace and including most of Pine Bluff, waters of the Quaternary aquifer range from moderately to very hard. Hardness values in low-flow streams correspond to the hardness values in the ground water of the drainage area. When flows are sustained by discharge, maximum hardness in Bayou Bartholomew is about 150 mg/l.

k. Per Cent of Sodium.

The per cent of sodium influences the suitability of ground water for irrigation. The range of per cent sodium in Jefferson County is 4 to 93 per cent. Water from the Jackson-Cockfield aquifer is higher in per cent sodium than is that of the Sparta Sand or Quaternary aquifers (Tables IV-35 through IV-38.) With most irrigation water being drawn from the Quaternary aquifer, however, the water can be classified as good to excellent with respect to per cent sodium (Klein et al., 1950).

## E. RELATIONSHIPS AMONG SURFACE AND GROUND WATER QUALITY AND THE STUDY AREA ENVIRONMENT. (Most of this section has already been addressed in various segments of Section IV).

1. *Surface Water Quality*.

As detailed in Section IV.B. and Figure IV-1, the quality of surface waters is interrelated with all of man's activities and land use practices (Figure III-2), as well as the physiography and climate of the Study Area. The latter determines the potential quality of surface waters and the former determines their realized quality. Water quality in turn molds the structure and composition of aquatic populations (Section VI.B) and much of the overall esthetic, recreational, domestic and industrial uses of the waters (Sections VIII and II.D.4). Figure IV-7 illustrates some of the inter-relationships of surface water quality to the various elements and activities of the Pine Bluff Study Area.

2. Ground Water Quality.

Ground water quality is excellent in the Study Area and because it has no restricted demands, it has been an important factor in the area's growth and development. Currently, and in the foreseeable future, ground water quality will remain good and will meet all projected needs. Although Bayou Bartholomew serves as a recharge source for the Quaternary aquifer, it has not degraded the aquifer's water quality. However, this may change with future deterioration of the bayou's waters.

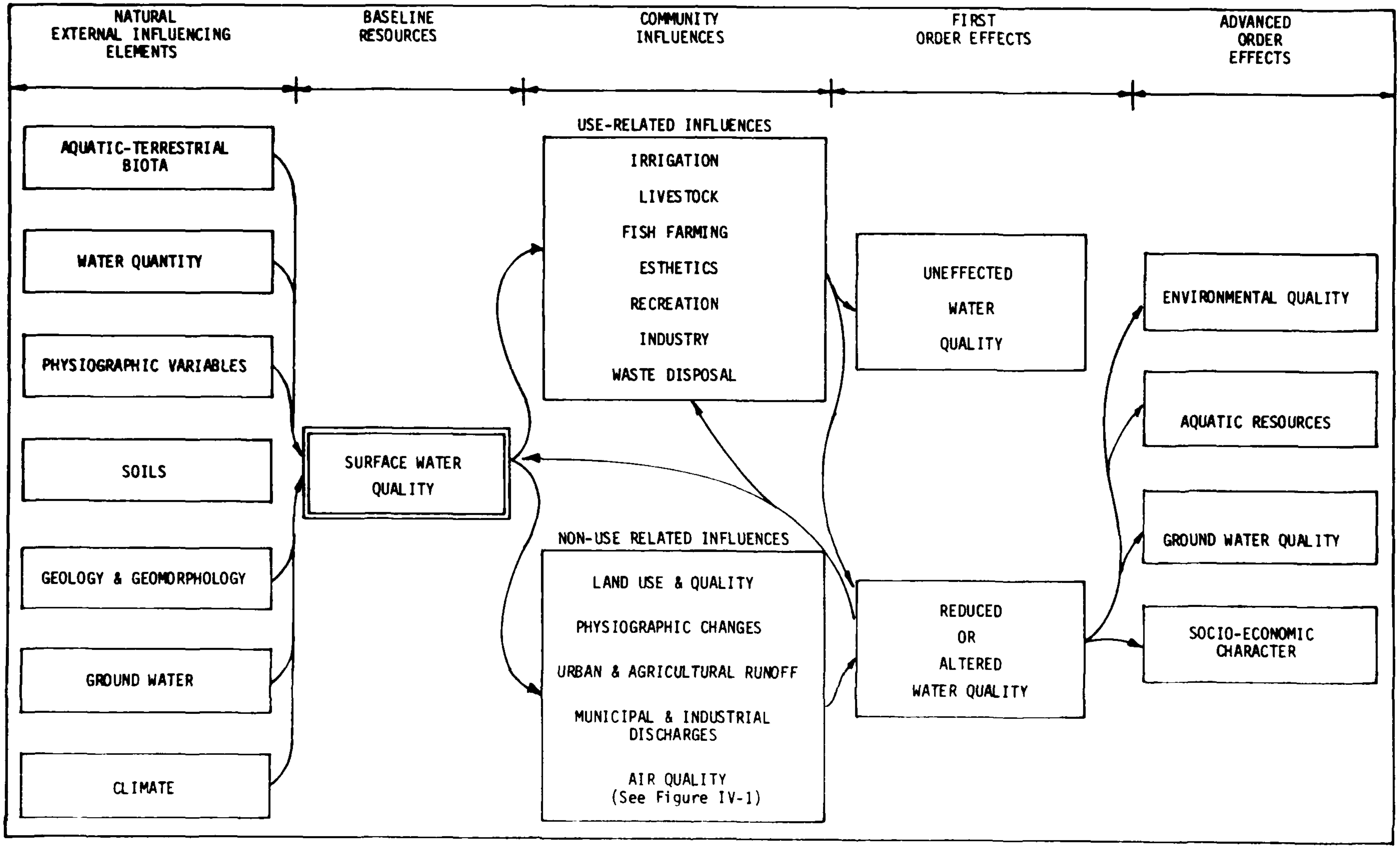



FIGURE IV-7: INTERRELATIONSHIPS OF SURFACE WATER QUALITY TO THE PINE BLUFF STUDY AREA

3. <u>Upstream Influences</u>.

With both Caney Bayou and Bayou Bartholomew having their headwaters within the Study Area, upstream influences (influences beyond the Study Area boundaries) are non-existent for these systems. The most important upstream occurrence directly affecting the Study Area is the Arkansas River and its impact to Lake Langhofer. Generally, adverse impacts to the lake appear to be minimal as can be judged by the lake's high water quality and biological diversity. The Arkansas River, however, is currently more stable in stage than in previous years with the construction of the McClellan-Kerr Navigation project and its associated locks and dams. This project has reduced stage fluctuations in Lake Langhofer and the seasonal flow of nutrients into its waters. Possibly, the additional nutrients could have enhanced the fisheries and other aquatic populations.

4. Downstream Effects.

a. Caney Bayou.

The waters of Caney Bayou flow into Lake Langhofer and from there into the Arkansas River. With the bayou's high concentration of nutrients and sanitary wastes (Section IV.6.), there is some enrichment of Lake Langhofer's waters and this is possibly a contributor to the lowered dissolved oxygen levels and lower benthic diversity encountered at Station 10b. Overall, however, the pollution load of Caney Bayou is well assimilated by the lake.

b. Bayou Bartholomew.

The downstream effects of Bayou Bartholomew are best described by the water quality of Station 5 (Bayou Bartholomew near Pinebergen). In general, baseflow water quality at Station 5 indicates a minimum of downstream impacts. During and following major storm events, however, there will be contamination by fecal bacteria, nutrient enrichment and perhaps depleted oxygen levels. Sediment derived from upstream erosion is also carried beyond the limits of the Study Area. The consequence of upstream loadings on the downstream biological populations will be felt for some distance depending on concentration of the loading and flow.

F. FUTURE WATER QUALITY PROJECTIONS.

1. Stormwater Quality Projections.

Future stormwater quality projections expressed as average annual loads for selected parameters were made for the years 1985, 2000 and 2020. The projections, although highly speculative, were based on an analysis of existing conditions (Section IV.B.), future growth and development patterns (Section III), and the implementation of future projects potentially affecting stormwater quality (Section III). As sanitary wastes are a dominant factor in the existing stormwater quality, the various projects and time schedules of the Pine Bluff Sewerage Master Plan as developed by M. Crist and Associates (1970) were followed carefully. In some instances, however, the scheduling was modified to bring specific sewerage projects in tune with the foresight of 1975.

The quantified projections, as presented in Tables IV-39 and IV-45, are based on volume-frequency relationships and load-frequencies (U.S. Army Corps of Engineers, Vicksbury District, pers. comm.) and a subjective analysis of future stormwater quality conditions. Methodologies for stormwater runoff load analysis are appended (Appendix C: "Collection and Analysis Methods"), as are pollution loads by station and storm (Tables C-69 through C-75 appended) and pollution load frequencies by station (Tables C-76 through C-82 appended).

a. Station 7 (Lower Caney).

The dominant forces molding the future water quality of stormwater runoff at Station 7 will be improvements to the existing sanitary sewage collection and treatment facilities and increased industrial and other urban growth. Table IV-39 summarizes the various counterbalancing influences to water quality through projections of average annual loads for selected stormwater quality parameters.

(1) 1985 Stormwater Quality.

Sewerage system improvements planned for 1985 include the construction of new collection and trunk sewer lines for the developed and developing areas of Oakland and Dollarway sub-basins and connections with most of White Hall to their recently implemented collection and treatment facility. By 1985, most of the unsewered areas which presently exist will be eliminated, which, in turn, will reduce much of the discharge of raw sewage effluents to drainage ditches which now combines with stormwater runoff. Effluent from the sewage oxidation ponds of 1985 are anticipated to retain the same concentrations of constituents, but their flows may increase slightly, particularly that of White Hall which will serve most of the projected developments in that area. Some current flow to the Caney pond will be diverted into the projected Bartholomew oxidation ponds. The primary impact of sewerage improvements will be to slightly increase nutrient loads and decrease concentrations of organics and fecal bacteria.

Projected urban-type development for the Station 7 drainage area, including industrial growth, is relatively small for the next ten year period (Figure III-4). New industries, along with existing ones will continue to use oxidation pond treatment of waste waters unless more stringent treatment requirements are imposed during this time. While their sewage effluents will enhance nutrients, organics and solid concentrations, the total impact of the industrial waste water flows to Caney Bayou will be minor compared to those of municipal effluents. New residential developments will be sewered, and are expected to contribute a proportionate share of fecal bacteria, organics and suspended solids.

The combined and somewhat compensating impacts of sewerage facilities and increased urban development on 1985 water quality are presented in Table IV-39 and are determined primarily by increases in steady-state contributions and decreases in storm related contributions.

Table IV-39
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 7

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters)<br>Fecal Streptococcus Bacteria (per 100 milliliters) | 18,334<br>6,329 | 18,000<br>6,000 | 18,000<br>8,000 | 20,000<br>9,000 | Initial decrease with elimination of raw sewage discharges, partially offset by urban surface runoff and increased flows. Followed by slight increase with more runoff and gradual deterioration of collection system. |
| $BOD_5$ (lbs)<br>COD (lbs) | 763,000<br>4,766,000 | 1,075,000<br>5,462,000 | 537,000<br>2,035,000 | 645,000<br>3,414,000 | Increases initially with industrial growth and increased oxidation flows; followed by marked reduction by aeration and removal of industrial effluents; slight increases by 2020 with industrial and urban runoff and deterioration of system. |
| Total Kjeldahl Nitrogen (lbs)<br>Total Phosphorus (lbs) | 302,000<br>44,900 | 388,000<br>56,000 | 403,000<br>60,000 | 417,000<br>64,000 | 1985 increases expected with full implementation of Whitehall oxidation and increased urban runoff and sediment loads; only minor changes following 1985 with increased runoff and conversion of $NH_4$ to $NO_2$ in 2000. |
| Suspended Solids (lbs) | 25,589,000 | 48,000,000 | 54,000,000 | 60,000,000 | Parallels growth and projected construction activity which is concentrated between 1974 and 1985. |
| Oils & Grease (lbs) | 230,000 | 288,000 | 383,000 | 479,000 | Parallels increasing industrial and commercial runoff. |

*Actual
Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

(2) Stormwater Quality.

By the year 2000, additional sanitary sewer lines and a storm sewer relief outfall line entering the Caney Pond are planned to be in place. In addition, plans for improved sewage treatment include mechanical aerators to be installed on the Caney ponds. These improvements will increase the flow capacity of the ponds, but will markedly reduce the organic load of the Caney Pond and eliminate the current problems of occasional surcharges of raw sewage flows from the existing outfall line.

Industrial growth will continue in the drainage area through this period, but the construction of a new collection system and force main to the Kansas Street pumping station industrial sewer will eliminate the industrial oxidation ponds. Industrial growth will account for the majority of urban-type growth (0.9 per cent; Table IV-39) projected for 2000. Residential growth will be minimal.

Overall, the year 2000 should see only minor reductions in water quality, although additional sanitary waste problems will arise with aging of the collection system (Table IV-39).

(3) 2020 Stormwater Quality.

Relatively few sewerage improvements will be made during this 20-year period, based upon current planning. Urban-type development will be small and primarily industrial in nature, as for the preceding 15-year period.

b. Station 8a (Brumps Bayou).

The major changes in land use for Brumps Bayou, as forecasted in the baseline conditions (Section III) will be the relocation of the existing railroad and the sewering of residences in the western portions of the watershed. Only the latter, scheduled for the late 1970's, will significantly affect stormwater quality. Existing runoff conditions, erosion and problems with sewage collection (Section IV.B.4.) are considered to be constants for the projections of average annual loads. Additionally, urban-type developments are not forecasted for the three target years.

With the elimination of most septic tanks by 1985, the stormwater quality of Brumps Bayou will improve slightly, with decreases in fecal bacteria, organic and nutrient concentrations. This may be offset, however, with increased frequency of surcharges and gradual deterioration of the sewerage collection system. The water quality of the years 2000 and 2020 will deteriorate slightly from that of 1985. Table IV-40 summarizes the projected water quality as average annual loads for selected water quality parameters.

c. Station 1 (Bayou Bartholomew at Princeton Pike Road).

In the absence of major urban development, and with projected sewerage improvements (M. Crist and Associates, 1970) for the drainage basin of Princeton Pike, the projected average annual loads for the target years whould remain relatively unchanged (Table IV-41). Only slight increases in fecal bacteria and suspended solids are indicated between 1975 and 1985, accompanying a 0.4 per cent conversion of lands to urban-type development.

Table IV-40
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 8a

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 89,076 | 85,000 | 87,000 | 89,000 | Decrease in 1985 with elimination of home septic tanks; gradual increase with system deterioration. Fecal Streptococci mainly of animal origins. |
| Fecal Streptococcus Bacteria (per 100 milliliters) | 53,824 | 51,000 | 52,000 | 53,000 | |
| $BOD_5$ (lbs) | 56,600 | 52,000 | 55,300 | 56,600 | Slight decrease with elimination of septic tanks followed by gradual increase with system deterioration. |
| COD (lbs) | 323,000 | 305,000 | 314,000 | 323,000 | |
| Total Kjeldahl Nitrogen (lbs) | 18,900 | 17,300 | 18,200 | 19,100 | Same as above. |
| Total Phosphorus (lbs) | 2,921 | 2,360 | 2,550 | 2,830 | |
| Suspended Solids (lbs) | 1,781,000 | 1,781,000 | 1,781,000 | 1,781,000 | Reflects the absence of development. |
| Oils & Grease (lbs) | 7,686 | 7,686 | 7,686 | 7,686 | Reflects the absence of development. |

*Actual
Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

Table IV-41
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 1

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 1,661 | 1,700 | 1,700 | 1,700 | Minimal change in the absence of major changes in land use. |
| Fecal Streptoccus Bacteria (per 100 milliliters) | 1,300 | 1,360 | 1,360 | 1,360 | |
| $BOD_5$ (lbs) | 119,000 | 113,000 | 113,000 | 113,000 | No change. |
| COD (lbs) | 862,000 | 852,000 | 852,000 | 852,000 | |
| Total Kjeldahl Nitrogen (lbs) | 51,100 | 45,000 | 45,000 | 45,000 | No change. |
| Total Phosphorus (lbs) | 919 | 919 | 919 | 919 | |
| Suspended Solids (lbs) | 2,450,000 | 3,984,000 | 3,984,000 | 3,984,000 | Minimal change in absence of major changes in land use. |
| Oils & Grease (lbs) | 98,700 | 107,000 | 107,000 | 107,000 | As above. |

*Actual

Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

d. Station 2 (Interceptor Canal).

The stormwater quality of Interceptor Canal is currently dominated by storm-induced sewerage discharges and severe stream bank erosion. The former problems will not be ameliorated with implementation of the projected sewerage improvements, but the channel embankment should be partially stabilized by 1985; further channel improvements are not anticipated past this date, although limited revegetation will continue. Land use, with the exception of the railroad relocation, is considered a constant through the year 2020. The projected average annual loads for Station 2 aregiven in Table IV-42 which indicates significant changes only in suspended solids and total Kjeldahl nitrogen in response to reduced stream bank erosion.

e. Station 3 (Bayou Bartholomew at Highway 15).

The existing water quality of Station 3 is now affected significantly by the urban area; specifically, by the storm discharges of sediment and sewage by Interceptor Canal. This will remain relatively unabated over the following 45 years. In addition to the continuation of existing conditions, the major impact to future stormwater quality will be accelerated urban growth within the watershed. Table IV-43 summarizes the various compensating influences to water quality through projections of average annual loads for selected parameters.

(1) 1985 Stormwater Quality.

Urban-type development will be most pronounced over the next ten-year period. The sub-basins of Lower Nevins, Watson Chapel and Middle Bartholomew will experience 23, 22 and 18 per cent increases in urban-type development, respectively. The urban increase for the entire drainage area is estimated at 5.3 per cent. Accompanying this development will be the implementation of a separate sewerage system with collection and trunk sewer lines and a 140-acre treatment facility (oxidation ponds) located along Bayou Bartholomew downstream from Station 3. It is not anticipated, however, that the developing sewerage system will accommodate the projected growth and by 1985, there will be significant quantities of raw or partially treated sewage discharged into Bayou Bartholomew during storm events. In addition to sewage, the new developments will introduce urban surface wastes and large quatities of sediment and urban wastes. In summary, there will be a major increase in all pollution parameters by 1985.

(2) 2000 and 2020 Stormwater Quality.

Growth will be slow over the next 35-year period and it is anticipated that most, but not all, development will be included in the sewerage collection system. This will reduce the sewage discharges, but urban runoff wastes, and to a lesser extent sediment, will still be elevated. For the watersheds most active in urban-type growth (Lower Nevins, Watson Chapel and Middle Bartholomew) there will be a 5, 3 and 10 per cent increase, respectively, by 2000 and a 0, 3and 5 per cent increase, respectively, by 2020.

f. Station 4 (Outlet Canal).

The current stormwater quality of Station 4 is dominated by sewage exfiltration from septic tanks and old collection and trunk lines which

Table IV-42
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 2

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 48,223 | 48,000 | 49,000 | 50,000 | Gradual minor increases with deterioration of sewerage collection system. |
| Fecal Streptococcus Bacteria | 39,794 | 40,000 | 40,500 | 41,000 | |
| $BOD_5$ (lbs) | 5[illegible],900 | 53,000 | 53,000 | 61,000 | As above. |
| COD (lbs) | 321,000 | 321,000 | 331,000 | 340,000 | |
| Total Kjeldahl Nitrogen (lbs) | 21,900 | 1[illegible],000 | 17,000 | 17,000 | As above but with initial improvement in Total Kjeldahl nitrogen with reduced sediment loading. |
| Total Phosphorus (lbs) | 1,199 | 1,330 | 1,330 | 2,000 | |
| Suspended Solids (lbs) | 7,594,000 | 4,700,000 | 3,900,000 | 3,[illegible]00,000 | Improvement with decrease in bank erosion; nature of channel is such, however, that erosion will never be eliminated. |
| Oils & Grease (lbs) | 24,300 | 24,300 | 24,300 | 24,300 | No change. |

*Actual

Source: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

Table IV-43
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 3

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 24,108 | 60,000 | 40,000 | 35,000 | Fecal coliform increase initially in response to rapid urban growth and gradually decreases with completion of sewerage collection system. Fecal streptococci somewhat independent of human wastes will remain elevated. |
| Fecal Streptoccus Bacteria (per 100 milliliters) | 30,843 | 32,000 | 32,000 | 32,000 | |
| $BOD_5$ (lbs) | | | | | Organics increase in response to urban runoff and erosion -- the rate is slowed, however, with elimination of sewage discharges by 2000. |
| COD (lbs) | 4,084,000 | 5,740,000 | 6,750,000 | 7,090,000 | |
| Total Kjeldahl Nitrogen (lbs) | | | | | Nutrients increase initially in response to urban growth and begin to decline with sewerage system implementation. Erosion will maintain total nitrogen and phosphorus. |
| Total Phosphorus (lbs) | | | | | |
| Suspended Solids (lbs) | 27,434,000 | 50,600,000 | 50,600,000 | 36,200,000 | Parallels urban-type growth; decreases with increased urban revegetation. |
| Oils & Grease (lbs) | 326,000 | 337,000 | 360,000 | 393,000 | Parallels urban-type growth and increasing streets. |

*Actual

Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

make up most of the sewerage system of the drainage area. Surface runoff and erosion are also significant. As projected growth in the drainage area is minimal, future water quality will be determined largely by the implementation of the Sewerage Master Plan. Table IV-44 presents the projected average annual loads for the years 1985, 2000, and 2020 at Station 4.

(1) 1985 Stormwater Quality.

By 1985, stormwater quality will improve with the elimination of an estimated 60 per cent of the currently unsewered residential wastes. Specific projects include a new pumping station and force main at Mississippi Street and new trunk and collection lines along South Ohio Street and in the eastern portions of the drainage area (M. Crist and Associates, 1970). The old collection lines, some over 80 years old will not be replaced and will continue to deteriorate and counterbalance other improvements. Development will increase only 1 per cent between 1975 and 1985.

(2) 2000 and 2020 Stormwater Quality.

Growth will be minimal during this period (less than 1 per cent) and the completion of the sewerage plan will eliminate an estimated 90 per cent of the unsewered residential wastes. Deterioration of existing and newly implemented lines will continue. Stormwater quality as reflected by average annual load data will improve slightly by 2000 and remain relatively unchanged by 2020 (Table IV-44).

g. Station 5 (Bayou Bartholomew near Pinebergen).

Although the drainage system is comprised primarily of forested and cleared lands, the current stormwater quality of Station 5 is dominated by upstream loadings. Future stormwater quality will be a function of many counteracting forces: deteriorating water quality of Bayou Bartholomew at Highway 15, improving water quality in Outlet Canal, and perhaps most significantly, the effluent of oxidation ponds projected to be developed approximately seven miles upstream. Urban-type development of the drainage area of Station 5 will be minor: 5, 1 and 1 per cent for the years 1985, 2000 and 2020, respectively. Table IV-45 summarizes these counterbalancing forces through projections of average annual loads.

(1) 1985 Stormwater Quality.

The dominant factors in determining the deteriorated water quality of Station 5 in 1985 will be two 70-acre-cell oxidation ponds and the serious degradation of waters in the vicinity of Highway 15 (Station 3). Offsetting these will be improved discharges of Outlet Canal, natural backwater ponding and dilution from the relatively unpolluted waters of Sandy Creek. All parameters reflective of pollution will be expected to increase.

(2) 2000 and 2020 Stormwater Quality.

With gradual improvements in the stormwater quality of stations 3 and 4, there will be slight decreases in the levels of fecal bacteria, organics, and solids. Nutrient levels will continue to increase in response to the projected enlargement of the Bartholomew oxidation pond system in 2000 and 2020.

Table IV-44
Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
Station 4

| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 75,337 | 45,000 | 35,000 | 37,000 | Fecal coliforms will decrease in response to new sewerage facilities counteracted by continued discharges from old existing lines. Fecal streptococci will remain relatively constant. |
| Fecal Streptococcus Bacteria (per 100 milliliters) | 30,648 | 28,000 | 26,000 | 26,000 | |
| $BOD_5$ (lbs) | 169,000 | 108,000 | 92,000 | 92,000 | Organics follow patterns equivalent to fecal coliforms. |
| COD (lbs) | 802,000 | 727,000 | 683,000 | 683,000 | |
| Total Kjeldahl Nitrogen(lbs) | 61,300 | 55,000 | 50,000 | 50,000 | Total nitrogen decreased only slightly as it is correlated with sediment. Inorganic nitrogen and phosphorus will decrease slightly with new sewerage system; changes for the latter will be minor, however. |
| Total Phosphorus (lbs) | 4,247 | 2,100 | 2,100 | 2,100 | |
| Suspended Solids (lbs) | 9,592,000 | 9,352,000 | 8,015,000 | 8,015,000 | Parallels growth trends and gradual stabilization of openlands. |
| Oils & Grease (lbs) | 50,700 | 56,000 | 56,000 | 56,000 | Little change in absence of major changes in land use. |

*Actual

Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

## Table IV-45
## Projected Stormwater Bacterial Concentrations and Average Annual Loads for Selected Chemical Parameters
## Station 5

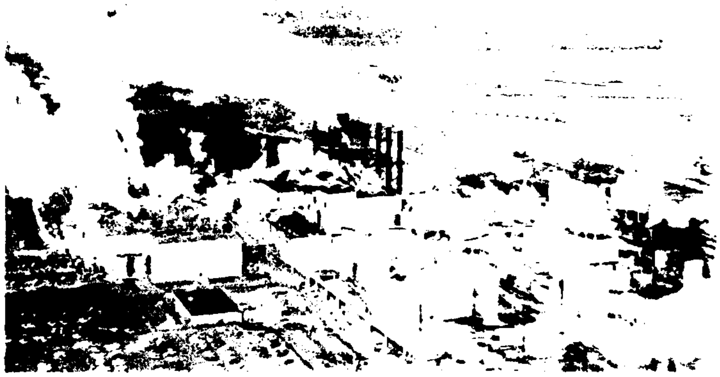
| CONSTITUENT | 1974* | 1985 | 2000 | 2020 | REMARKS |
|---|---|---|---|---|---|
| Fecal Coliform Bacteria (per 100 milliliters) | 10,681 | 35,000 | 30,000 | 30,000 | Initial increase with oxidation pond effluents and unsewered developments above Highway 15; improvements foreseen with upstream improvements. |
| Fecal Streptococcus Bacteria (per 100 milliliters) | 3,921 | 20,000 | 15,000 | 15,000 | |
| $BOD_5$ (lbs) | 1,293,000 | 2,351,000 | 1,881,000 | 2,116,000 | As above. |
| COD (lbs) | 6,785,000 | 7,700,000 | 7,365,000 | 7,588,000 | |
| Total Kjeldahl Nitrogen (lbs) | | | | | Nutrients initially increase markedly in response to oxidation pond effluents (see existing conditions of Station 7) and slowly thereafter with smaller pond additions. Upstream non-point sources also contribute. |
| Total Phosphorus (lbs) | 16,054 | 80,270 | 112,000 | 112,000 | |
| Suspended Solids (lbs) | 81,7[illegible],000 | 134,000,000 | 115,000,000 | 96,000,000 | Primarily in response to urban-type growth above Highway 15; improving with slowed growth and stabilization of open areas. |
| Oils & Grease (lbs) | 700,000 | 770,000 | 805,000 | 840,000 | Increases in response to increased urban-type development. |

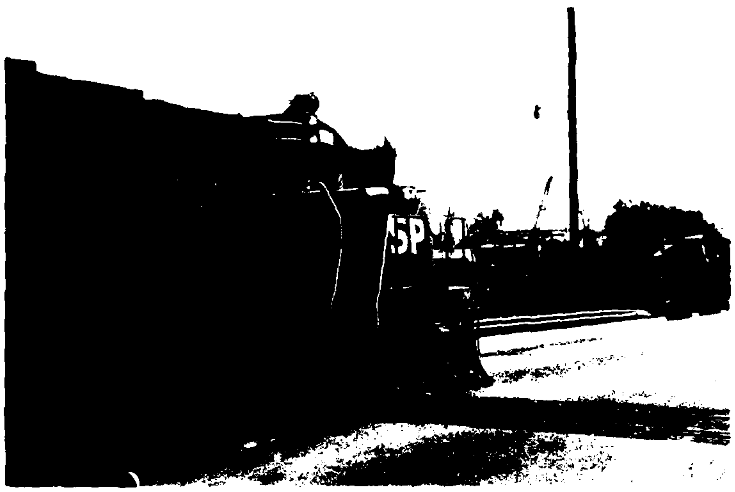
*Actual

Sources: U.S. Army Corps of Engineers, Vicksburg District (pers. comm.) and VTN Louisiana, Inc.

2. Ground Water Quality.

Although future ground water use has not been determined, ground water quality of both the Sparta Sand and the Quaternary aquifers is not projected to change over the next 45 years. Pumpage due to excessive demands on the Sparta Sand Aquifer, however, could increase its mineral and chloride content. Moreover, as Bayou Bartholomew serves as a source of recharge for the Quaternary Aquifer, severe degradation of the bayou's waters could in turn affect the water quality of the aquifer.






# AIR QUALITY AND NOISE

# V

# V
# AIR QUALITY AND NOISE

## A. INTRODUCTION.

This chapter deals with air quality and noise in the Study Area. A discussion on the Federal and State laws and guidelines relevant to the Study Area is presented, along with a description of the current ambient air quality and the expected noise environment of the Pine Bluff Metropolitan Area.

## B. AIR QUALITY.

### 1. Federal, State and Local Standards.

The enactment of the Clean Air Act Amendments of 1970, instructed the U.S. Environmental Protection Agency (EPA) to publish regulations prescribing both National primary and secondary ambient air quality standards for each air pollutant for which air quality criteria had been issued prior to the date of enactment. The National primary ambient air quality standards, allowing an adequate margin of safety, are requisite to protect public health. The National secondary ambient air quality standards are requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of an air pollutant in the ambient air (U.S. Environmental Protection Agency, 1970). In April, 1971, EPA established standards for major air pollutants: sulfur dioxide ($SO_2$), particulate matter, carbon monoxide (CO), hydrocarbons (HC), nitrogen oxide ($NO_x$) and photochemical oxidants. The primary and secondary standards for these pollutants are presented in Table V-1.

The State of Arkansas enacted the Arkansas Air Pollution Control Code, as amended, on July 7, 1972. The Arkansas Department of Pollution Control and Ecology (ADPCE) is the State agency that is responsible for enforcement of the Air Code. However, there are no local agencies currently enforcing air regulations.

### 2. The Pine Bluff Metropolitan Area Air Quality Survey.

The Pine Bluff Air Quality Survey began on April 1, 1974, to collect ambient air quality data in order to compare the National primary and secondary standards and applicable State regulations. In order to measure present ambient air quality, the ADPCE has, in agreement with the U.S. Army Corps of Engineers, Vicksburg District, undertaken a survey of hydrogen sulfide, sulfur dioxide, total sulfur and suspended particulate matter in the Pine Bluff Metropolitan Area.

Four sampling stations are presently operating in the Pine Bluff Study Area (Figure V-1). Specific locations and parameters being monitored at each station are listed in Table V-2. Quality assurance on sulfur dioxide, hydrogen sulfide, total suspended particulates and total sulfur compounds was carried out using methods sanctioned by the EPA. Pine Bluff emission sources are listed in Table V-3.

TABLE V-1

NATIONAL AMBIENT AIR QUALITY STANDARDS

| POLLUTANTS | AVERAGING TIME | PRIMARY | SECONDARY |
|---|---|---|---|
| Sulfur Dioxide | Annual Arithmetic Mean | 80 mg/m3 or (0.03 ppm) | - |
| | 24 Hours | 365 mg/m3 or (0.14 ppm) | - |
| | 3 Hours | - | 1300 mg/m3 or (0.5 ppm) |
| Suspended Particulate Matter | Annual Geometric Mean | 75 $mg/m^3$ | 60 $mg/m^3$ |
| | 24 Hours | 260 $mg/m^3$ | 150 $mg/m^3$ |
| Carbon Monoxide | 8 Hours | 10 $mg/m^3$ or (9 ppm) | 10 $mg/m^3$ or (9 ppm) |
| | 1 Hour | 40 $mg/m^3$ or (35 ppm) | 40 $mg/m^3$ or (35 ppm) |
| Photochemical Oxidants (Total) | 1 Hour | 160 mg/m3 or (0.08 ppm) | 160 mg/m3 or (0.08 ppm) |
| Hydrocarbons | 3 Hours | 160 mg/m3 or (0.24 ppm) | 160 mg/m3 or (0.24 ppm) |
| Nitrogen Dioxide | Annual Arithmetic Mean | 100 mg/m3 or (0.05 ppm) | 100 mg/m3 or (0.05 ppm) |

SOURCE: U. S. Environmental Protection Agency, 1973.

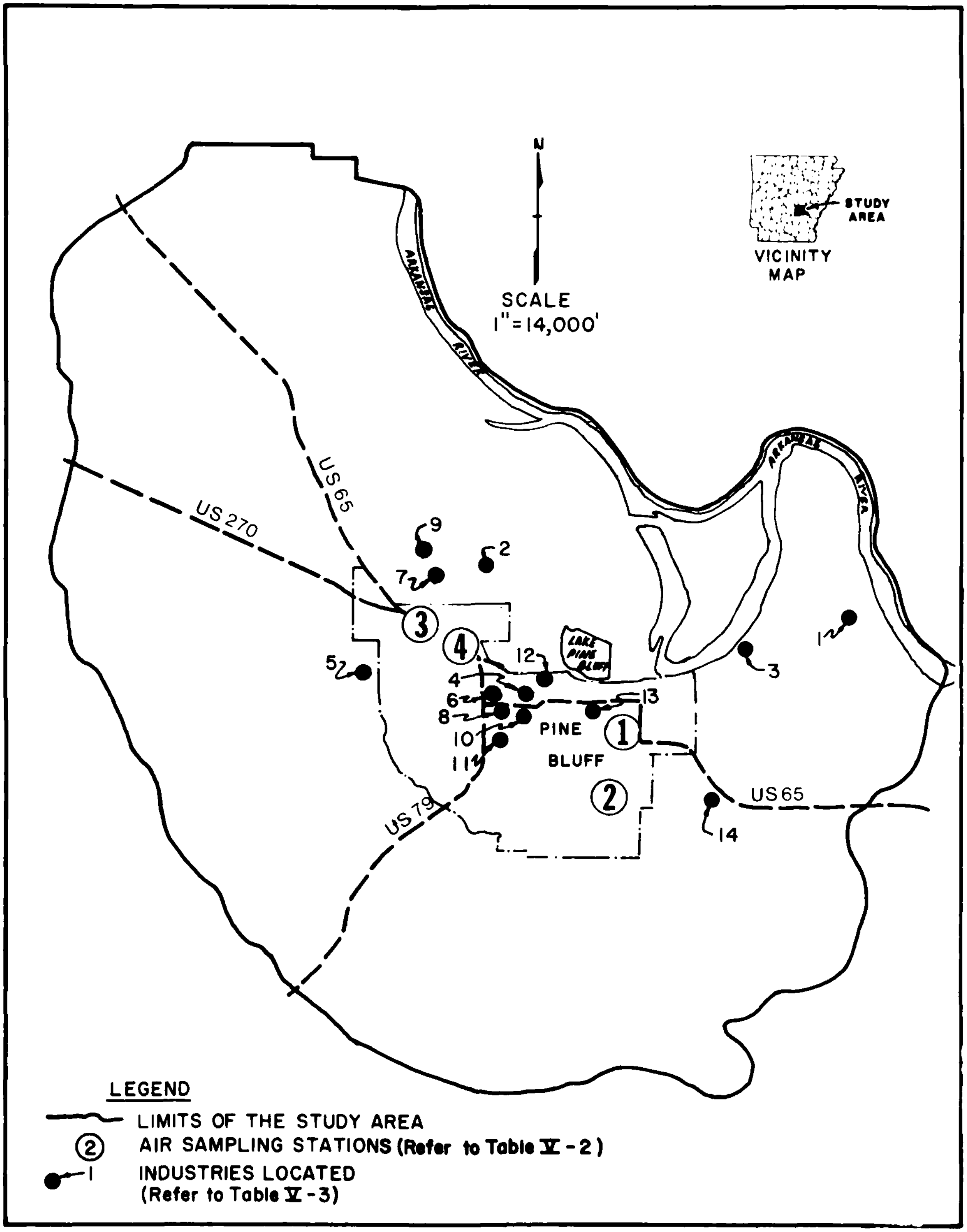



FIGURE V-1: AIR SAMPLING STATIONS OF THE PINE BLUFF STUDY AREA

Source: Arkansas Department of Pollution Control and Ecology, 1974b.

TABLE V-2

LOCATION OF AIR QUALITY MONITORING STATIONS
AND PARAMETERS BEING TESTED IN PINE BLUFF
(see Figure V-1)

| STATION | LOCATION | PARAMETERS |
|---|---|---|
| 1 (24 hr.) | Pine Bluff Municipal Center (10th and State) | a) Sulfur Dioxide<br>b) Hydrogen Sulfide<br>c) Total Suspended Particulates |
| 2 (24 hr.) | American Legion Building (3200 Main Street) | a) Sulfur Dioxide<br>b) Hydrogen Sulfide<br>c) Total Suspended Particulates |
| 3 (24 hr.) | Fire Station No. 6 (1805 Moreland Street) | a) Sulfur Dioxide<br>b) Hydrogen Sulfide<br>c) Total Suspended Particulates |
| 4 (Continuous) | 4605 Dollarway Road | a) Sulfur Dioxide<br>b) Hydrogen Sulfide<br>c) Total Sulfur |

Source: Arkansas Department of Pollution Control and Ecology, 1974b.

TABLE V-3

PINE BLUFF EMISSION SOURCES
(SEE ALSO FIGURE V-1)

| INDUSTRY | TYPE | Particulate Emissions Tons/yr | $SO_2$ Maximum Potential Tons/day |
|---|---|---|---|
| International Paper Co.[1] | Papermills | 6790 | 15 |
| Weyerhaeuser[2] | Papermill | 3925 | 2.5 |
| Pine Bluff Sand & Gravel[3] | Paving Mixture | 403 | - |
| Arkansas Oak Flooring Co.[4] | Finished Lumber | 127 | - |
| Jos. E. Seagrams & Sons, Inc.[5] | Cooperage | 215 | - |
| W.S. Fox & Sons, Inc.[6] | Sawmills | 112 | - |
| Independent Aluminum[7] | Foundry | 3 | - |
| Brown Manufacturing[8] | Furniture | 3 | - |
| Dixie Wood Preserving[9] | Lumber | 1 | - |
| Ben Pearson[10] | Machine Shop | 4 | - |
| Central Maloney[11] | Power Transformers | 2 | - |
| Standard Brakeshoe[12] | Foundry | 5 | - |
| Cook Industries[13] | Cottonseed Processors | 245 | - |
| D & R Boat Company[14] | Builders | ? | - |

Source: Arkansas Department of Pollution Control and Ecology, 1974b.

To date, there have been three Quarterly Reports published by the ADPCE. A summary of the air quality survey for stations 1, 2 and 3 is given in Table V-4. The data for Table V-4 was obtained from the nine month sampling program beginning on April 1, 1974, and running through December 31, 1974. Table V-5 presents the air quality data obtained from Station 4 (Arkansas Department of Pollution Control and Ecology, 1974b). The data summarized for the period of record (April 1 through December 31, 1974), giving the highest instantaneous reading (HIR), the highest hourly average (HHA), and the highest daily arithmetic mean (HDAM) in both parts per billion (ppb) and micrograms per cubic meter ($mg/m^3$).

Dustfall measurements were made in Pine Bluff from 14 January to 20 February, 1975, at four stations (Table V-6) and heavy metal analyses were made at three of those four stations (Table V-6) from 5 April, 1974 to 31 March, 1975. Concentrations of copper were highest at Station 3 (Figure V-1), but were consistently below 0.41 $ug/m^3$; lowest at Station 1 (Figure V-1), below 0.18 $ug/m^3$. Mercury concentrations were consistently below 0.005 $ug/m^3$ at all stations. During the 31 sampling periods, the vanadium concentrations exceeded zero (to 1.41 $ug/m^3$) only at Station 1 (28 June - 21 August, 1974). Lead concentrations remained below 1.59 $ug/m^3$ throughout, except at Station 1 once in October (2.26 $ug/m^3$). There are no National air quality standards for heavy metals at present.

3. Relationship of Air Quality to the Study Area.

The development of a region will result in an impact on the quality of air, whether from new stationary sources, such as factories and power plants, or from increased automobile traffic.

Inferior air quality can affect human health and safety, cause injury to plant and animal life and property, decrease the comfort and convenience of the people, and reduce the social development of and the enjoyment of the natural resources of the area.

High particulate matter concentrations will result in economic and esthetic losses such as a decrease in visibility and an increase in soiling and corrosion.

The emission of smoke, suspended particulate matter or uncombined water can create a traffic hazard by impairing visibility or intensifying existing hazardous traffic conditions.

Atmospheric and terrestrial moisture in its various phases is the final weather element of notable import to air pollution. It is generally appreciated that precipitation, i.e., rain and snow, is probably the most effective cleansing agent in the atmosphere (Stern, 1968). This precipitation will eventually develop into the runoff entering the streams and lakes. This can alter the water quality of the receiving body, thereby reducing the quality of the habitat for fish and wildlife, fish farming, recreation, and industrial and agricultural uses.

Relative humidity is also a key parameter for the formation of pollutant materials such as sulfuric acid mists which are physiologically damaging to

TABLE V-4

SUMMARY OF AIR QUALITY SURVEY DATA
FOR THE PINE BLUFF STUDY AREA
STATIONS 1, 2 AND 3
(APRIL 1 THROUGH DECEMBER 31, 1974)

| POLLUTANT | AVERAGING TIME (9 months) | RESULTS | | |
|---|---|---|---|---|
| | | 1* | 2 | 3 |
| Total Suspended Matter | Geometric Mean | 49 $mg/m^3$ | 43 $mg/m^3$ | 57 $mg/m^3$ |
| | 24 Hour Maximum | 126 $mg/m^3$ | 144 $mg/m^3$ | 135 $mg/m^3$ |
| Sulfur Dioxide | 24 Hour Maximum | <25 $mg/m^3$ | <25 $mg/m^3$ | <25 $mg/m^3$ |
| Hydrogen Sulfide | Maximum Concentration | 7.3 $mg/m^3$ | 69 $mg/m^3$ | 3.3 $mg/m^3$ |

*STATION NUMBERS

SOURCE: Arkansas Department of Pollution Control and Ecology, 1974b.

TABLE V-5

SUMMARY OF AIR QUALITY SURVEY DATA
FOR THE PINE BLUFF STUDY AREA STATION 4
(APRIL 1 THROUGH DECEMBER 31, 1974)

| POLLUTANT* | DATE | TIME | RESULTS |
|---|---|---|---|
| Sulfur Dioxide: | | | |
| HIR | Aug. 1, 1974 | 1:00 p.m. | 37.6 ppb or 96.8 $mg/m^3$ |
| HHA | Aug. 23, 1974 | 12:00 p.m. | 21.9 ppb or 56.4 $mg/m^3$ |
| HDAM | Dec. 1, 1974 | - | 6.4 ppb or 16.0 $mg/m^3$ |
| Hydrogen Sulfide: | | | |
| HIR | Apr. 18, 1974 | 10:00 a.m. | 62.0 ppb or 84.9 $mg/m^3$ |
| HHA | Oct. 25, 1974 | 11:00 a.m. | 27.9 ppb or 38.1 $mg/m^3$ |
| HDAM | Sep. 8, 1974 | - | 8.4 ppb or 11.5 $mg/m^3$ |
| Total Sulfur: | | | |
| HIR | Aug. 14, 1974 | 8:00 a.m. | 214.1 ppb or 551.1 $mg/m^3$ |
| HHA | Aug. 14, 1974 | 9:00 a.m. | 66.2 ppb or 170.4 $mg/m^3$ |
| HDAM | Sep. 8, 1974 | - | 5.9 ppb or 15.2 $mg/m^3$ |

* See text for explanation of HIR, HHA and HDAM.

SOURCE: Arkansas Department of Pollution Control and Ecology, 1974b.

TABLE V-6

DUSTFALL IN THE PINE BLUFF METROPOLITAN AREA
JANUARY 14 - FEBRUARY 20, 1975

| STATION LOCATION | DUSTFALL RATE/MONTH TONS/$MI^2$/MONTH |
|---|---|
| Fire Station #6, Moreland * | 6.67 |
| Municipal Center * | 7.67 |
| 619 Fifth Street | 9.95 |
| American Legion, 3200 Main Street * | 4.56 |
| MEAN | 7.21 |

* Also heavy metal sampling stations.

SOURCE: Arkansas Department of Pollution Control and Ecology, pers. comm.

animal tissues. Relative humidity and soil moisture have been noted to exert a marked effect upon the sensitivity of plants to phytotoxic air pollutants (Stern, 1968).

Injury to vegetation by air pollutants results not only from industrial sources, but also from sources associated with the complexities of urban living. The effects of these pollutants on vegetation are important, not only from the standpoint of economic loss, but also because of the use of vegetation damage as a means of monitoring and defining the extent of the pollution complex. Vegetation loss also results in habitat loss for fishes and wildlife and increases erodibility of soils (especially along streams) which results in siltation problems which further reduce biological productivity.

Dustfall can also cause injury to health and property. In addition, its intermittent flushing can cause a substantial increase in the organic load of a receiving stream.

4. Summary of Pine Bluff Air Quality.

During the Pine Bluff Air Quality Survey which was operative from April 1, 1974 through March 31, 1975, no hourly or annual standards (National or State) were exceeded. It should be noted that only total suspended matter and sulfur dioxide are the only parameters sampled for which National Standards have been promulgated.

a. Particulate Matter.

The daily secondary standard for particulate matter was exceeded by 1 ug/$m^3$ at one sampling site because of a localized problem. Data indicated an exceptionally good air quality; however, it should be noted that the rain fall for the survey period was above normal and may have contributed to the low concentrations of particulate matter. These particulate concentrations have been lower than those expected for a city the size of Pine Bluff and for the amount of nearby automobile traffic of the sampling sites.

b. Sulfur Compounds.

Concentrations of sulfur compounds in the City of Pine Bluff are relatively low and are apparently of no consequence as a detriment to health. There are no significant sources of sulfur dioxide in the Study Area, nor are there any major sources of hydrogen sulfide in the Pine Bluff area. Two Kraft Mills do, however, release sulfides in odorous concentrations which affect the area only when winds are from a northerly or northeasterly direction.

c. Dustfall.

In Pine Bluff, the higher dustfall occurred within the urban center and diminished northward and southward. However, all data indicate that concentrations are well below the National averages and that no dustfall problem exists in the Study Area.

d. Heavy Metals.

Heavy metals do not present a threat to the Study Area. No concentrations of cadmium were detected at any of the sampling stations and only low concentrations of the other metals were detected.

## C. NOISE.

### 1. Federal, State and Local Standards.

The U.S. Environmental Protection Agency's noise control activities are authorized by the Noise Pollution and Abatement Act of 1970 (Title IV of the Clean Air Act), and the Noise Control Act of 1972. These acts directed EPA to identify and classify causes and sources of noise and determine their effects on public health and welfare. The EPA was also instructed to develop criteria with respect to noise and publish information on levels of environmental noise required to protect public health and welfare, and to identify major sources of noise and propose emission standards for identified major sources of noise.

Currently, the Arkansas Department of Pollution Control and Ecology manages the noise program for both State and local municipalities. The nature of the program consists primarily of survey and monitoring along with answering nuisance complaints (Bragdon, 1974).

### 2. Noise in The Study Area.

The following discussion involves noise in the Study Area. It is based on a thorough literature review and analysis of comparable sources of a similar setting. There have been no environmental noise monitoring problems carried out within the Study Area to date. Also included are the results of interviews conducted by members of the Pine Bluff Urban Water Management Study Citizens Advisory Committee concerning noise. Background noises in seven areas were surveyed: 1) industrial areas, 2) port areas, 3) railroad yards, 4) airport facilities, 5) major highways, 6) congested areas, and 7) the central business district. Included with the above is a discussion on the various environmental impacts of noise pollution, including the impacts on the social and economic environment and the effect noise has on the wildlife and other animals of the Study Area.

The outdoor noise environment varies greatly in magnitude and character among various locations throughout a community - from the quiet suburban areas bordering on farm land to the din of traffic in the downtown city canyon. It generally varies with time of day in each location, being relatively quiet at night when people-type activities are at a minimum and noisier in the late afternoon during the 5 o'clock traffic rush.

a. Expected Noise Levels in the Study Area.

The following is a description of the anticipated noise levels that occur in the various types of land use areas. These anticipated noise levels are based on comparable noise levels of a similar setting, which have been documented in the literature (Table V-7).

TABLE V-7

NOISE LEVELS AND COMMON SOURCES

| SOUND QUALITY | dB(A) | SOUND SOURCE |
|---|---|---|
| Uncomfortably Loud | 120 | |
| | | Turbojet (118) |
| | | Propeller Aircraft (115) |
| | 110 | |
| | | Rock Band (108-114) |
| | | Boeing 707 @ 6,080 ft. (106) |
| Very Loud | 100 | |
| | | Power Mower (96) |
| | 90 | |
| | | Motorcycle (90) |
| | | Loud Street Noises (90) |
| | | Industrial Ambient Sound (85-100) |
| | | Diesel Train, 45 mph @ 100' (83) |
| | 80 | |
| | | Urban Ambient Sound (80) |
| | | Passenger Car, 65 mph @ 25' (77) |
| | | Freeway @ 50' from Pavement Edge (76) |
| Moderately Loud | 70 | |
| | | Heavy Traffic (64) |
| | 60 | |
| | | Commercial Ambient Sound (50) |
| Quiet | 50 | Normal Conversation (50) |
| | 40 | |
| | | Suburban Ambient Sound (35-40) |
| Faint | 30 | Rural Ambient Sound (30) |
| | 20 | |
| | 10 | Forest (rustle of leaves) (10) |
| Very Faint | | |
| Threshold of Audibility | | Sound Proof Room (3) |
| | 0 | |

SOURCE: U. S. Environmental Protection Agency, 1971a.

(1) Residential.

The characteristic noise levels of residential areas depend on the location of the residences and the time of day. Table V-7 indicates suburban noise levels will range from 35 to 40 db(A) (decibels "A" weighted), during the entire day. As one approaches the central business district, the sound levels will increase because of surrounding ambient levels. Typical dense urban environments have noise levels of 80 db(A). This level will obviously vary according to the time of day being as high as 90 db(A) during peak rush hour traffic and as low as 50 db(A) at night (U.S. Environmental Protection Agency, 1971a).

(2) Industrial.

The sound pressure levels produced by industrial sources other than transportation vehicles are difficult to specify in simple terms because industrial buildings have many sizes and shapes, and the composite sources of sound may have a complicated configuration. Industrial ambient sound will range from 85 to 100 db(A). However, after the usual business hours there is, of course, a decrease in the noise of industrial operations and of traffic, since the traffic is usually reduced (U.S. Environmental Protection Agency, 1971e).

(3) Commercial.

The typical noise levels of commercial areas tend to be the same as ambient levels of the area they are located in. Commercial activities have noise levels around 50 db(A). They usually do not add to the ambient sound level unless located in suburban areas (U.S. Environmental Protection Agency, 1971e).

(4) Rural.

Rural ambient sound levels are similar to suburban areas, with the exception of less traffic in the rural setting. Typical noise levels in rural areas are approximately 30 db(A) (U.S. Environmental Protection Agency, 1971d).

(5) Public Lands.

Both recreational and institution lands will have ambient noise levels similar to the surrounding terrain.

(6) Transportation.

Vehicular traffic will display various sound pressure levels both on the ground and in the air. With regard to transportation, sound pressure levels will vary with the type of vehicle and the type of thoroughfare traveled. Passenger cars on interstate highways exhibit sound pressure levels of about 76 db(A). In heavy traffic, the level drops to 64 db(A). Motorcycles emit noise levels of 90 db(A). Inner city street noise can be as loud as 90 db(A) and louder. This high level is attributed not only to vehicular traffic but to construction and repairing operations. Airports and

air traffic also add to the din of community noise. Propeller aircraft have noise levels of 115 db(A). The levels of noise found in the area of an airport will vary considerably according to the number of takeoffs and landings (U.S. Environmental Protection Agency, 1971d).

(7) Forested Lands.

The rustle of leaves has a sound pressure level of 10 db(A). Noise from a forested area is normally quite low with the exception of logging operations; however, even with logging, noise levels decreased rapidly away from their source because of the interference of the surrounding trees (U.S. Environmental Protection Agency, 1971c).

b. Encountered Noise in the Study Area.

The following is a brief discussion of noise in each of Pine Bluff's potential problem areas. The discussion is based on a survey performed by members of the Pine Bluff Urban Water Management Study Citizens Advisory Committee, where 20 households in each of the following potential noise areas were interviewed. Questions covered these topics: 1) location and source of noise, 2) regularity, and 3) degree of annoyance. Subtopics of annoyance included questions concerning speech disruption, sleep awakening, physical discomfort (headaches) and no effect of noise.

Decibel levels can be associated with each of the three annoyance subtopics: 1) speech disruptions - 60 db(A), 2) sleep awakening - 90 db(A), and 3) physical discomfort (headaches) - 120 db(A).

(1) Industrial Areas.

The primary target area for industrial noise in Pine Bluff is the industrial area immediately west of the central business district. Three of 20 people complained of being awakened occasionally by a nightly 11:30 p.m. whistle at a local lumber company. Otherwise, only one person complained of any physical discomforts due to the effects of noise. None complained of speech disruption in these areas.

(2) Port Areas.

The survey did not cover the area adjoining the Pine Bluff Port, as 1) few residences are found in close proximity to the area, and 2) those residences nearest the port would be more adversely affected by the nearby railroad switching yards.

(3) Railroad Yards and Tracks.

Households in proximity to the railroad switching yards and those persons living within several blocks of heavily-used railway corridors in Pine Bluff were interviewed for noise problems. Of 20 households interviewed, two complained of speech disruption, six complained of being awakened by passing trains and 14 either indicated no effect or at worst, not being able to hear the television. None complained of physical discomforts due to railroad noise. Most complaints of sleep awakening emanated from West 3rd Street and Howard Drive.

(4) Airport Facilities.

Of the 20 households interviewed near the vicinity of Grider Field, only one person complained of being awakened from sleep occasionally. No households complained of speech disruption or of any physical discomforts resulting from propeller or jet plane noise levels.

(5) Major Highways.

Those households in closest proximity to U.S. Highway 65 and Dollarway Road were interviewed for noises emanating from highway traffic (automobiles, trucks, motorcycles). One household on Pullen Street and one on Dollarway Road complained of day and night speech disruption because of highway noise. Six households in the same area complained that highway noises occasionally awakened them. Two persons of 20 interviewed complained of headaches caused by highway noise-related discomforts.

(6) Congested Areas.

Twenty households living along such congested areas as Hazel Street, Olive Street, West Harding and Cherry Street were interviewed. Three households on Cherry and Olive streets complained of noise levels causing sleep awakening. One of these households on Cherry Street also complained of speech disruptions and physical discomforts caused by considerable automobile horn blowing. Cherry Street is a major attractant of area youths who drive up and down the street, honking horns at each other in recognizance.

(7) Central Business District.

Twenty businesses in the downtown district on and near Main Street were interviewed concerning noise levels. No complaints of speech disruption and physical discomfort were encountered.

3. Relationship of Noise to the Study Area.

The following is a brief discussion on the relationships of noise to the social and economic environments along with the effects on wildlife and other animals.

a. Social Environment.

Noise has often been cited as a major source of annoyance as well as a threat to physical and mental health because of its pervasive influence in all settings, activities and walks of life. For most people, the usual consequences of noise are associated with interference with listening to speech or other sounds, distraction at home and on the job, disturbance of rest and sleep, and disruption of recreational pursuits. The noise problem has compounded because urbanization and the increased concentration of population bring about more exposure to the ordinary sounds of living.

Noise has a number of characteristics in common with other environmental pollutants. Another common feature is that it is extremely difficult to establish simple casual relationships between the pollutant and its effects.

Recent studies related to the impact of noise on the social environment resulted in a variety of interpretations. However, there is general agreement on the following factors related to noise:

1) Noises of sufficient intensity have caused irreversible hearing damage;

2) Noises have produced psychological changes in humans and animals that in many instances have not resulted in adaptation;

3) Since the effects of noise are cumulative, the levels and durations of noise exposure must be taken into account in any overall evaluation;

4) Noises can interfere with speech and other communication;

5) Noise can be a major source of annoyance by disturbing sleep, rest and relaxation;

6) When community noise levels have reached sufficient intensity, social action has reacted to reduce their effects (U.S. Environmental Protection Agency, 1971a).

b. Economic Environment.

The impact of noise to the economic environment is difficult to assess primarily because of the lack of data on noise levels and an inadequate understanding of the effects of noise. It is apparent that aircraft noise is presently a major problem with substantial economic costs. Practical as well as economic considerations suggest that it is generally preferable to attempt to abate noise at the source, rather than to insulate the noise receiver. With the continuing trends in growth in noise generators and in urban/suburban population concentrations, noise could become a much more serious problem in the near future.

Research on the economics of noise has increased in the past year or so in that more emphasis has been placed on such things as 1) quieter jet engines, 2) reduction of noise in industry, 3) economic impact on property values, and 4) effect of noise from household appliances (U.S. Environmental Protection Agency, 1971b).

c. Wildlife and Other Animals.

In recent years, the possible effects of noise on wildlife have become a matter of serious concern. The effects that increased noise levels will have on wildlife in these areas are virtually unknown. Obviously, animals that rely on their auditory systems for courtship and mating behavior, prey location, predator detection, homing, etc., will be more threatened by increased noise than will species that utilize other sensory modalities. However, due to the complex inter-relationships that exist among all the organisms in an ecosystem, interference with one species might well affect all the other species.

Noise pollution conceivably could disrupt a balanced ecosystem and possibly even contribute to the extinction of a vulnerable species. Many species of wildlife today are endangered. Apart from the threat of the irretrievable loss of a particular species, we have no certain knowledge regarding the possible effects of such a loss on our ecology. To prevent possible irreparable damage to wildlife and to the balance of nature, it is mandatory that we calculate the expected increases in noise levels and try to relate them to their possible impact on our wildlife.

4. Summary of Pine Bluff Noise Problems.

Ambient noise levels in the Pine Bluff urban area and surrounding areas pose no serious problems to the populace. Few people complained of noise interrupting their speech or sleep or of any other noise-related physical discomforts. Noise in two areas caused a degree of annoyance; sleep awakening was somewhat common along U.S. Highway 65 and along 3rd Street and Howard Drive. The former corridor carries considerable automobile and truck traffic; the latter areas adjoin heavily-traveled railroad routes. Overall, however, noise pollution does not appear to be a significant problem in the Study Area at this time.

# BIOLOGICAL RESOURCES

# VI

# VI
# BIOLOGICAL RESOURCES

A. STUDY AREA ECOSYSTEMS AND HABITATS.

Jefferson County and the Study Area are largely forested and dissected by many natural and some channelized streams. The entire area is also dotted with many permanent and temporary lakes and ponds. These aquatic ecosystems provide a wide variety of lentic and lotic habitats. The uplands and bottomlands of the county and Study Area are productive forest and wildlife areas. The mild climate which affords a long growing season, the rich soils, and the numerous and varied plant species provide a wide variety of habitats for terrestrial and semi-terrestrial game, fur-bearing and non-game mammals, reptiles and amphibians, resident and transient game and non-game birds, and numerous insects and other invertebrates.

B. AQUATIC RESOURCES.

1. Introduction.

Although the Study Area is characterized by various lakes, ponds and streams, very few limnological reconnaissance studies have been made in the area. The Arkansas Game and Fish Commission has surveyed fish populations and tested several water quality parameters in Lake Langhofer and Lake Pine Bluff (Arkansas Game and Fish Commission, pers. comm.). The U.S. Army Corps of Engineers has done limited limnological testing in Caney Bayou (U.S. Army Corps of Engineers, Vicksburg District, pers. comm.). The U.S. Army Arsenal at Pine Bluff has also done limnological work at its facility (U.S. Army Arsenal, pers. comm.).

Overall, little information is available concerning the plants and animals in the various aquatic habitats or concerning the physicochemical parameters operating therein. In order to establish baseline data concerning the existing conditions characterizing lentic and lotic habitats and their corresponding biotic communities, general reconnaissance studies were made within the Study Area (Plate VI-1).

2. Existing Conditions.

The Pine Bluff Study Area is a watershed boundary for both the Arkansas River and Ouachita River basins. Both basins are split into two primary physiographic regions: the rolling hills of the Coastal Plain in the headwater areas and the flat to gently undulating lands of the Alluvium downstream. The sampled stream systems are free-flowing, sluggish water bodies characteristic of the southeastern United States Coastal Plain. The sampled lakes are artificial; Lake Pine Bluff is an impoundment and Lake Langhofer is an oxbow-type lake.

In the following treatment of the aquatic resources, the parameters and communities measured and analized are treated first individually in Section VI.B.2.a. and secondly by station and/or streamreach in Section VI.B.2.b.

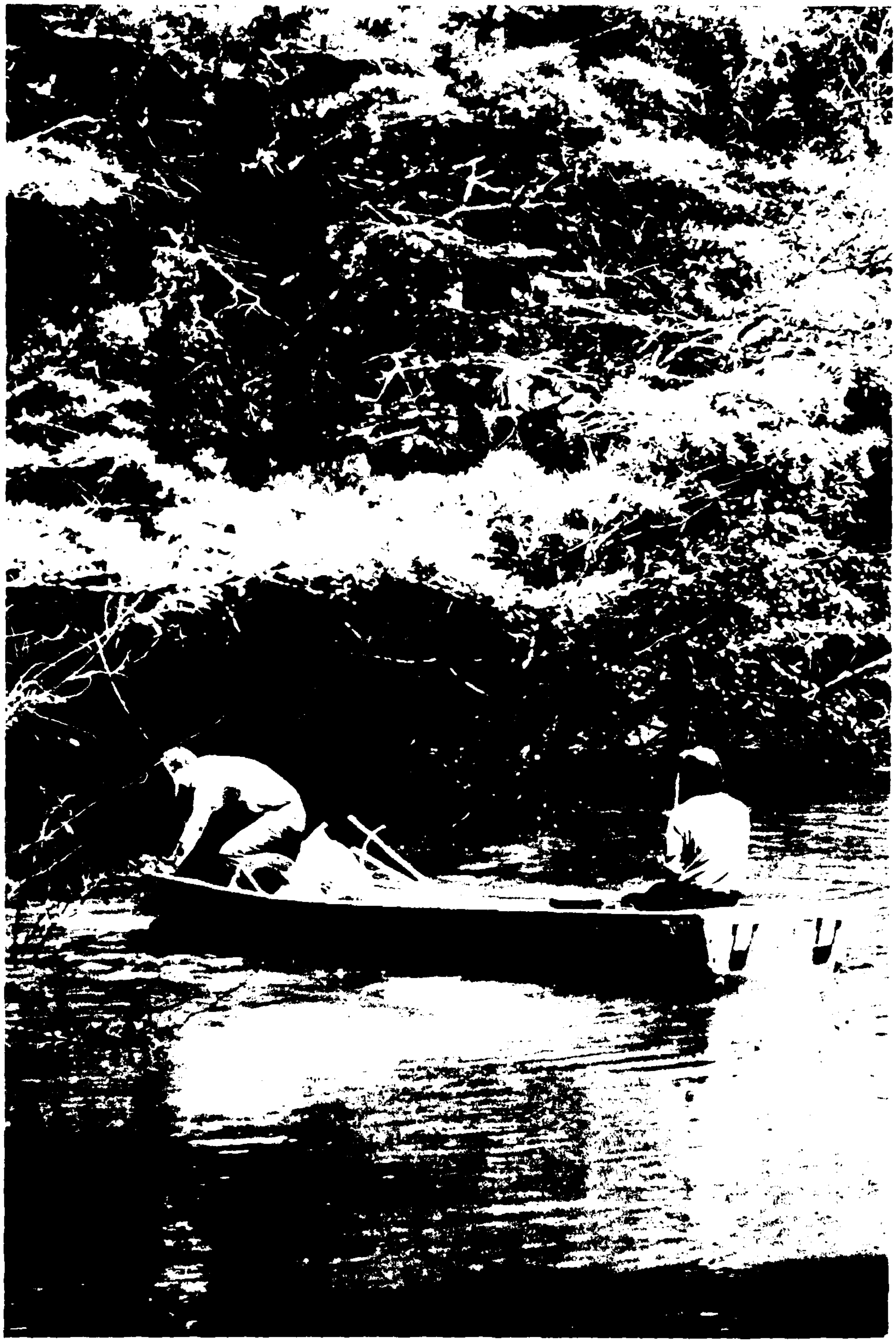


Plate VI-1  Rotenone sampling to determine fish communities in Bayou Bartholomew

a. Bottom Composition and Biological Communities Sampled in the Study Area.

The aquatic habitats selected for the general reconnaissance studies included four stream stations, two canal stations and two lake stations (Figure VI-1). This sampling program's results and analyses follow (see also Appendix D).

(1) Bottom Composition.

Bottom sediments play a variety of roles in determining habitat suitability for aquatic flora and fauna. Bottom substrates consisting primarily of shifting sand or scoured hard-pan clay provide few habitats for aquatic fauna. Substrates consisting of anaerobic sludge and silt likewise provide habitats for only the hardiest of benthic fauna. In the Study Area, bottom sediments of organic debris and varying clay, silt, sand and gravel composition reflect the generally sluggish nature of the streams and bayous. Riffle areas are usually uncommon in all but the headwater areas of streams. Pooled areas with a somewhat homogeneous mixture of clay, silt, sand and organic debris generally provide optimum habitat for aquatic invertebrates and vertebrates in the Study Area.

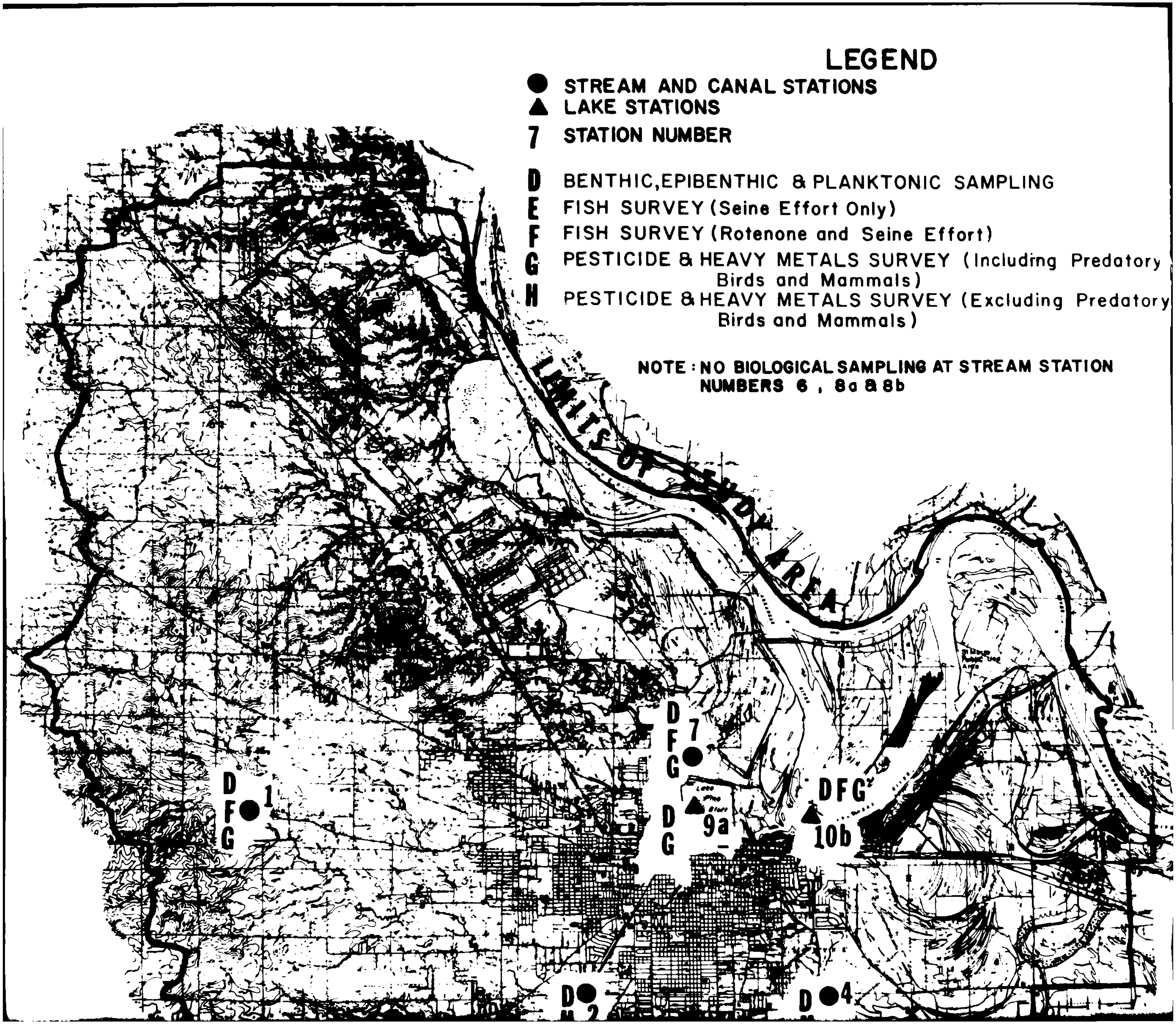
Gross percentages of clay, silt, sand, gravel, detritus and sticks for each station are presented in Table VI-1. Analyses indicated that no sticks were available as potential substrates for sessile and/or sedentary invertebrates in the bottom sediments at stations 2 and 4. Bottom composition at stations 2 and 10b were dominated by medium-sized sediments (gravel and sand), while stations 3, 4, 7 and 9a were characterized by finer-sized sediments (silt and clay). Stations 1 and 5 had a bottom composition of relatively equal amounts of fine and medium-sized sediments, although these sediments were not necessarily homogeneously dispersed throughout the stream channels at the sampling sites (see also Section VI.B.2.b.).

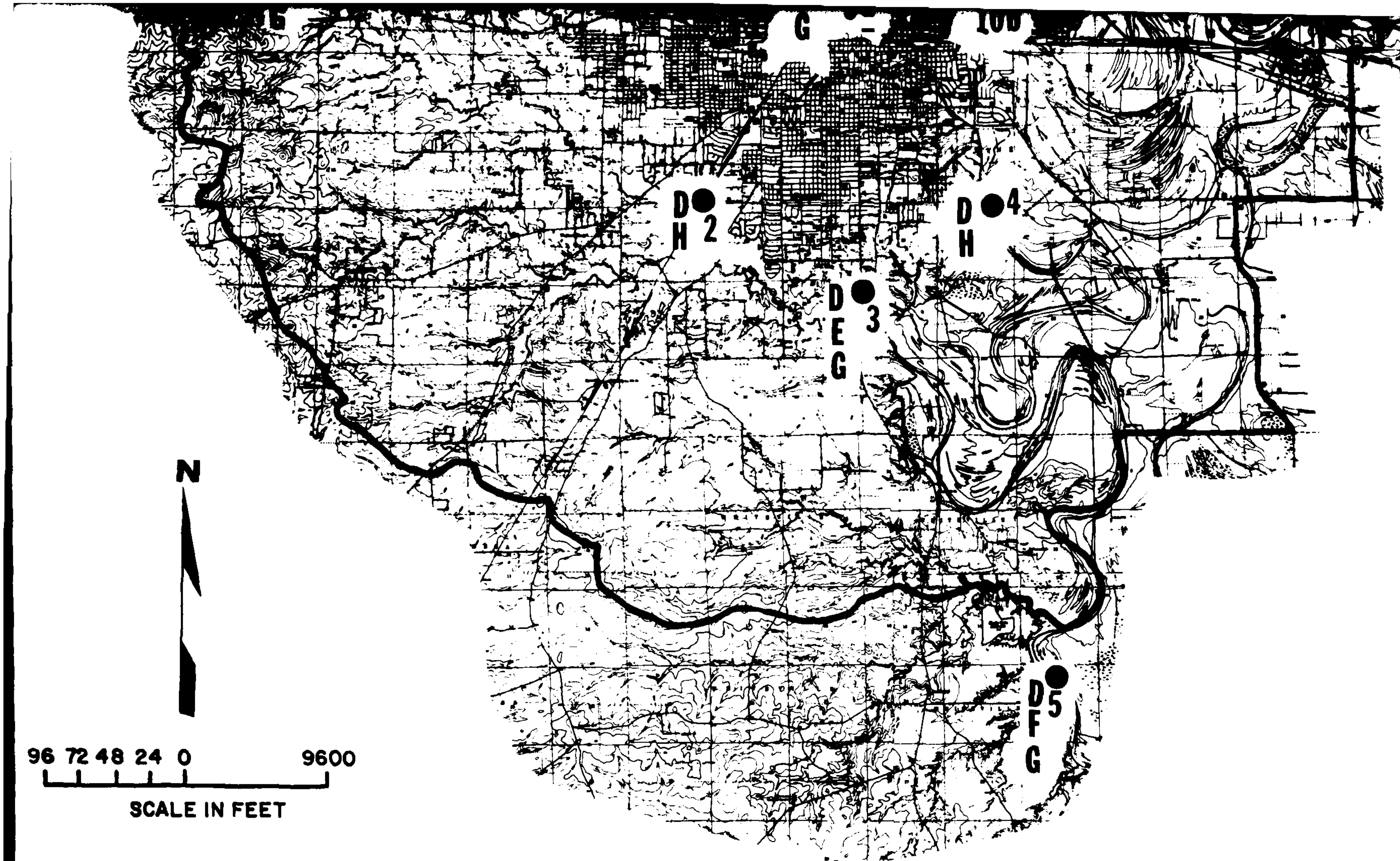
(2) Plankton.

Phytoplankton and zooplankton occupy the base of the aquatic food web and their abundance determines the diversity and abundance of higher organisms. The plankton community in well-shaded lotic systems is rarely as diverse and as numerous as that in lentic systems. The plankton communities of the Study Area streams usually reflect upstream ponding and pooled or backwater areas. The relative abundance of Study Area plankton is presented and discussed in Section VI.B.2.b. and species lists are appended (Tables D-1, D-3).

(3) Aquatic Vegetation.

Floating and emergent aquatic vegetation provide stream and lake ecosystems in the Study Area with shade, habitat and food for aquatic organisms. Rooted aquatics also prevent erosion by stabilizing the stream banks and lake shorelines. Certain emergent vegetation, such as alligatorweed (Alternanthera philoxeroides), can alter stream hydrology due to silt load precipitation in areas of plant abundance. Other plants, notably duckweeds (Lemna spp. and Spirodela spp.), are important because they remove inorganic nutrients from eutrophic waters. All aquatic plants also contribute organic detritus to the aquatic system, enriching the water and providing nutrients for the other primary producers. No submerged vegetation was noted at any Study Area station.


LEGEND
● STREAM AND CANAL STATIONS
▲ LAKE STATIONS
7 STATION NUMBER
D BENTHIC, EPIBENTHIC & PLANKTONIC SAMPLING
E FISH SURVEY (Seine Effort Only)
F FISH SURVEY (Rotenone and Seine Effort)
G PESTICIDE & HEAVY METALS SURVEY (Including Predatory Birds and Mammals)
H PESTICIDE & HEAVY METALS SURVEY (Excluding Predatory Birds and Mammals)
NOTE: NO BIOLOGICAL SAMPLING AT STREAM STATION NUMBERS 6, 8a & 8b
LIMITS OF STUDY AREA
D F G 1
D 2
D 4
D F G 7
D G 9a
DFG 10b




BIOLOGICAL SAMPLING STATIONS
OF THE PINE BLUFF STUDY AREA

FIG. VI-1

Table VI-1
Bottom Composition at Sampling Stations

| Station | | Bottom Composition | | | | | |
|---|---|---|---|---|---|---|---|
| Number | Location | % Sticks | % Detritus | % Gravel | % Sand | % Silt | % Clay |
| 1 | Bayou Bartholomew | 0.3 | 0.8 | 0.3 | 47.2 | 24.8 | 26.6 |
| 2 | Interceptor Canal | 0.0 | 0.7 | 6.8 | 62.8 | 17.1 | 12.6 |
| 3 | Bayou Bartholomew | 0.3 | 0.9 | 1.3 | 15.4 | 30.7 | 51.4 |
| 4 | Outlet Canal | 0.0 | 1.9 | 0.4 | 34.6 | 47.7 | 15.4 |
| 5 | Bayou Bartholomew | 0.1 | 1.2 | 0.4 | 50.1 | 29.0 | 19.2 |
| 7 | Caney Bayou | 0.2 | 1.4 | 0.6 | 23.6 | 37.4 | 36.8 |
| 9a | Brumps Bayou-Lake Pine Bluff | 0.9 | 1.8 | 0.9 | 31.2 | 28.8 | 36.4 |
| 10b | Lake Langhofer | 0.2 | 0.7 | 0.6 | 84.4 | 9.3 | 4.8 |

Aquatic vascular plants and their relative abundance are further treated in Section VI.B.2.b. A checklist of all vascular plants of the Study Area is appended (Table D-2).

(4) Benthic Communities.

Benthic communities were sampled during the spring and fall of 1974. Approximately 75 taxa of benthos were collected (Table D-4 appended). The biomass, number of individuals per square meter, number of taxa, and species diversity index (Table VI-2, Tables D-5 through D-12 appended) were computed for each station in order to assess the relative health of the sampling sites (see also Figure VI-2).

A knowledge of the relative abundance of a species is much more useful in evaluating environmental conditions than is just their presence or absence. Community composition is now recognized as being much more reliable than particular indicator organisms for evaluating environmental conditions (Gaufin, 1973). Additionally, a knowledge of water quality is needed for evaluating stream health, as water quality is reflected in the species composition and diversity, population density and physiological conditions of indigenous communities of aquatic organisms (Weber, 1973).

The relative abundance of species in terms of numbers, biomass and productivity have been summarized by researchers to indices of community diversity in order to attempt a quantification of the relative health of a stream (Cairns and Dickson, 1971; Egloff and Brakel, 1973; Wilhm and Dorris, 1966, 1968). The indices are dimensionless numerical expressions based on the assumption that under degraded conditions, numbers of species within the ecosystem will diminish and absolute numbers and biomass of the remaining species will increase. Diversity index values less than one have been obtained in areas of heavy pollution, values from one to three in areas of moderate pollution, and values exceeding three in clean water areas (Wilhm and Dorris, 1968).

While diversity indices have been used successfully in streams receiving point-source municipal or industrial discharges, less work has been accomplished in areas where non-point sources provide the vast majority of pollutants, as in the Pine Bluff area. Species diversity tends to be low in physically controlled ecosystems (i.e., subjected to strong physicochemical limiting factors) and high in biologically controlled systems (Odum, 1971). While contributions from uncommon species are minimal in low-diversity habitats, information from these species can become more important in habitats where biological control predominates, with concurrent low numbers of individuals and high numbers of species (Odum, 1971). For example, in a grossly polluted system dominated by 20,000 sludgeworms per cubic meter, the information contributed by five midge larvae is insignificant. However, in a clean water system where no taxon contributes more than ten individuals per cubic meter, the information from the five midge larvae is indeed significant.

Aquatic habitats in the Pine Bluff Study Area are under both physicochemical and biological control. Those stations primarily under biological control were stations 1, 3, 5 and 9b. Those primarily under physicochemical control were stations 2, 4, 7 and 9a.

Table VI-2
Biomass, Diversity and Numbers of Benthic Taxa and Individuals at Eight Pine Bluff Area Stations, April and November, 1974

| Station No. | Sampling Period | Biomass ($g/m^2$) | Diversity Index | No. of Taxa | Individuals/$m^2$ |
|---|---|---|---|---|---|
| 1 | Apr | 18.66 | 3.25 | 25 | 933 |
| | Nov | 2.25 | 2.89 | 17 | 1,258 |
| 2 | Apr | 150.44 | 1.23 | 13 | 10,182 |
| | Nov | 16.31 | 0.41 | 6 | 6,199 |
| 3 | Apr | 16.06 | 3.08 | 20 | 1,566 |
| | Nov | 9.77 | 2.87 | 17 | 1,209 |
| 4 | Apr | 529.99 | 0.59 | 5 | 68,191 |
| | Nov | 223.08 | 0.66 | 5 | 20,949 |
| 5 | Apr | 89.25 | 1.45 | 17 | 12,279 |
| | Nov | 3.95 | 2.32 | 17 | 1,962 |
| 7 | Apr | 54.25 | 2.81 | 15 | 2,369 |
| | Nov | 23.16 | 2.73 | 11 | 723 |
| 9a | Apr | 55.31 | 0.85 | 13 | 8,775 |
| | Nov | 119.94 | 0.34 | 9 | 44,105 |
| 10b | Apr | 14.23 | 2.62 | 23 | 2,065 |
| | Nov | 4.94 | 2.61 | 16 | 2,225 |

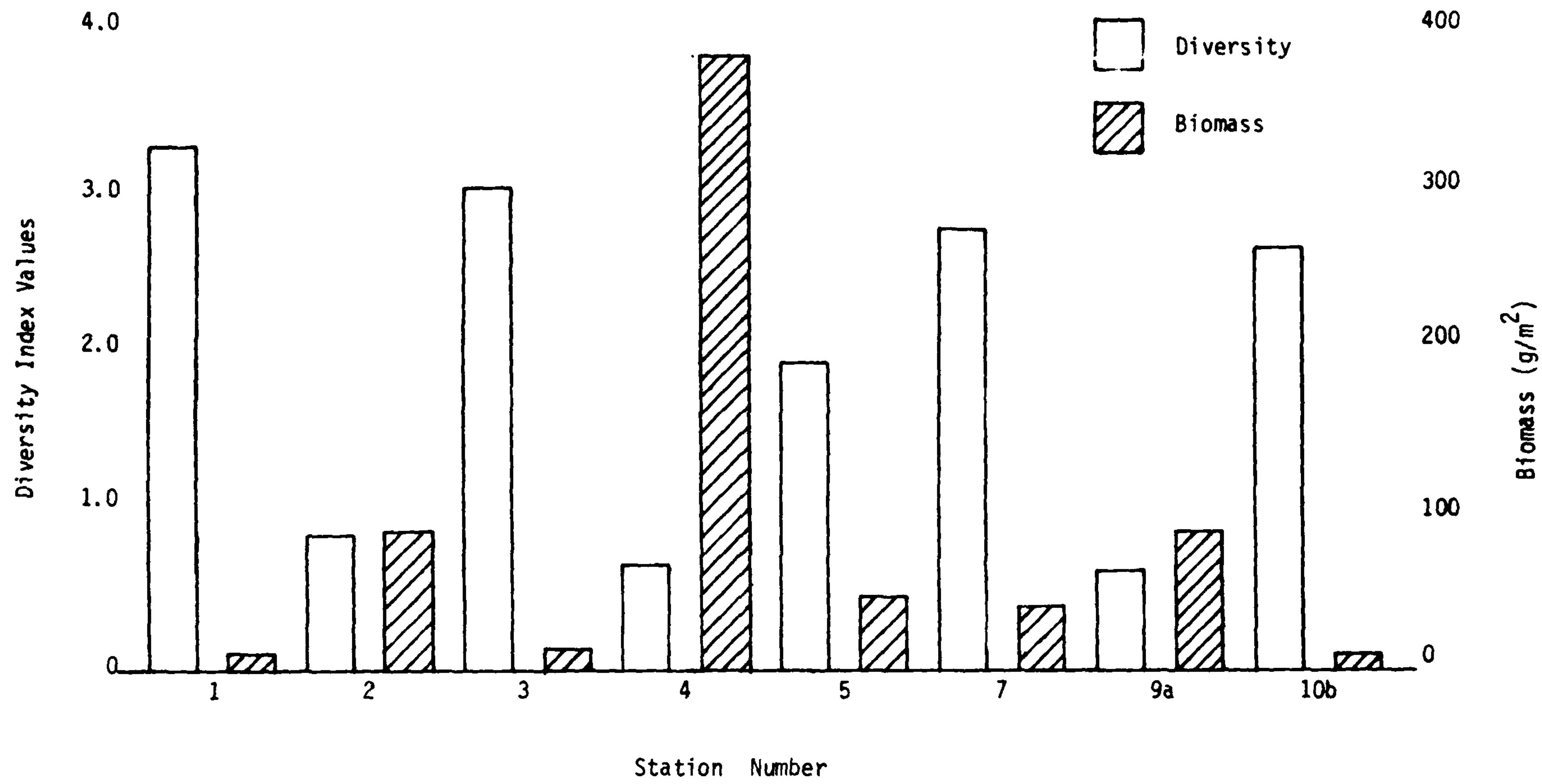



FIGURE VI-2: BENTHOS: COMPARATIVE MEAN BIOMASS AND DIVERSITY AT EIGHT STATIONS, APRIL AND NOVEMBER, 1974.

(5) Epibenthic Communities.

Epibenthos can be characterized as invertebrate life forms growing on, but not within, the bottoms of water systems or upon submerged vegetation or similar substrates. The term epibenthos is used here to include all macro-invertebrates found within the water column on various substrates. This definition excludes many benthos. Epibenthos were sampled in April and November in conjunction with benthic sampling; the methodology is appended (Appendix D). The number of taxa and catch per unit effort for each station are presented in Table VI-3; the enumeration of organisms collected is appended (Tables D-13 through D-21).

(6) Fish Communities.

As documented by the Pine Bluff public in the "Environmental, Recreational and Cultural Public Needs Questionnaire" (Section VIII.D), fishing is the primary outdoor sport in the area. Fish productivity is influenced by a number of factors: land use, habitat, water quality and predator-prey balance.

The occurrence of fishes and their relationship to other stream biota and physicochemical influences are presented in Section VI.B.2.b. Where only a few species which are considered tolerant of pollution were collected, the stream should not necessarily be considered a poor habitat for fish unless other stream sampling data verifies this (i.e., low benthic diversity, polluted water).

In the following discussions the species considered to be "game" fishes include: yellow bass *Morone mississippiensis*, white crappie *Pomoxis annularis*, black crappie *P. nigromaculatus*, largemouth bass *Micropterus salmoides*, sunfishes *Lepomis* spp. and *Centrarchus* spp., and channel catfish *Ictalurus punctatus*. All other fishes are considered "non-game." Table VI-4 contains catch per unit effort data for seine and rotenone samplings at Study Area stations. Biomass in terms of pounds per acre is not comparable among stations for either type of sampling because of sampling difficulties encountered. Snags, cypress knees, deep water, varying water velocities and varying fish responses to rotenone and seine sampling all served to bias the data.

(7) Aquatic-Oriented Reptiles and Amphibians.

Aquatic-oriented reptiles and amphibians are a taxonomically diverse assemblage found in a variety of habitats throughout the Study Area. It is difficult to assign species to specific aquatic systems with authority, and in the following account only generalities can be made. Suitability of Study Area habitats for herpetofauna is discussed in the station-by-station account. A more complete listing of amphibians and reptiles likely to occur in the Study Area is appended (Table D-28).

(8) Aquatic-Oriented Birds.

The diversity of aquatic areas in the Study Area fosters a rich and varied assemblage of aquatic-oriented bird life. The setting of the area provides a mixture of both upland and lowland habitats and the abundance of surface waters throughout attracts many nesting and migratory species. Suitability of Study Area habitats for avian fauna is discussed in the station-by-station accounts; habitat requirements and general Study Area abundance may be noted in Appendix D (Table D-29).

Table VI-3

Epibenthos: Number of Taxa and Catch Per Unit Effort For Each Sampling Station

| STATION NUMBER | NUMBER OF TAXA (APRIL/NOVEMBER) | NO. OF INDIVIDUALS PER UNIT EFFORT (APRIL/NOVEMBER) |
|---|---|---|
| 1 | 1/7 | 1/109 |
| 2 | 2/7 | 3/23 |
| 3 | 3/7 | 28/68 |
| 4 | 5/4 | 18/69 |
| 5 | 4/6 | 10/76 |
| 7 | 9/9 | 34/101 |
| 9a | 1/10 | 1/93 |
| 10b | 4/8 | 20/33 |

TABLE VI-4
Fish Catch Per Unit Effort, June, 1974

| | Seine | | | Rotenone | | |
| --- | --- | --- | --- | --- | --- | --- |
| Station No. | No. Bag Minnow Hauls | Lbs. Game | Lbs. Non-Game | Area* | Lbs. Game | Lbs. Non-game |
| 1 | 6/10 | 1.2 | 0.7 | ¼ ac | 9.3 | 4.7 |
| 3 | 6/10 | 1.2 | 1.9 | ---- | --- | --- |
| 5 | 2/4 | 0.1 | 0.09 | ¼ ac | 2.1 | 3.3 |
| 7 | --- | --- | --- | ¼ ac | 4.2 | 21.9 |
| 9a** | --- | --- | --- | 4 ac | 725.7 | 1929.7 |
| 10b | 6/8 | 0.2 | 1.6 | 1 ac | 111.8 | 201.3 |

* Estimated by Arkansas Game and Fish Commission, pers. comm.

** Data from 1973 sampling, Arkansas Game and Fish Commission, pers. comm.

(9) Aquatic-Oriented Mammals.

Study Area streams and lakes provide food and shelter for a variety of mammals. Certain mammals, such as beaver and muskrat, alter stream hydrology and thus provide additional habitats for other aquatic-dependent organisms. Dominant mammals are discussed by station; species lists, habitat preference and relative abundance in the Study Area are appended (Table D-30).

b. Organism-Habitat Relationships by Station and Streamreach.

The streamreach designation is as follows: Station 1 - Bayou Bartholomew headwaters to Shannon Road; Station 2 - the entire Interceptor Canal; Station 3 - Bayou Bartholomew from Shannon Road to Highway 15; Station 4 - the entire Outlet Canal below Ohio Street; Station 5 - Bayou Bartholomew from Highway 15 to Pinebergen; Station 7 - Caney Bayou from its headwaters to its Lake Langhofer confluence; Station 9a - Brumps Bayou-Lake Pine Bluff confluence; and Station 10b - Lake Langhofer between Boyd Point and the Caney Bayou confluence.

(1) Station 1 and Its Streamreach.

The upper reach of Bayou Bartholomew can be arbitrarily delineated from the headwaters in the northwestern quadrant of the Study Area to Shannon Road downstream (Figure VI-1). The monitoring and sampling station is Station 1 on Princeton Pike Road (Figure VI-1). The entire reach lies on the gently rolling Coastal Plain and its drainage area is primarily rural in character; forest communities of mixed hardwoods and managed pine dominate the land uses. The channel throughout the reach is relatively narrow, typically bounded by well-developed banks, and frequently braided into networks of smaller channels. Extensive backwater areas are absent. Frequently during mid summer its waters and associated aquatic life are confined to deeper pools and narrow depressions. The bottom configuration is heterogenous and its pools, gravel bars, small riffle areas, and narrow, relatively uniform sections allow for a diversity of aquatic habitats. Logs and other debris carried downstream by past storms are common and also contribute to the variety of habitats.

The water quality of the upper reach is generally good and is not a major limiting factor in the diversity of aquatic life. Dissolved oxygen levels are typically high (above 5 mg/l) except during the summer months. Turbidities and total solids are low and the water is relatively clear in appearance. Nutrients and organics are also low, but there is evidence of sanitary wastes entering the stream from rural residences and domesticated animals.

(a) Aquatic Vegetation.

Dominant streamside overstory vegetation includes river birch (*Betula nigra*), water oak (*Quercus nigra*), and blue beech (*Carpinus caroliniana*). Scattered along the upper reach are large, mature trees of sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), and red and white oak (*Quercus falcata* and *Q. alba*). Within the open shallow areas of the channel black willow (*Salix nigra*) and buttonbush (*Cephalanthus occidentalis*) are major vegetational elements often diverting the flows. Alligatorweed is present in small numbers only in the lower, wider segments of the streamreach.

The vegetation of upper Bartholomew is important in stabilizing streambanks, preventing severe erosion and providing habitats for aquatic and semi-aquatic animal life. The admixture of dense brush-like vegetation (willows and birches) and mature hardwoods in close proximity to the shallow braided channels of the bayou creates favorable feeding and nesting sites for a variety of aquatic-oriented reptiles, amphibians and birds. Roots of larger trees extending into the water, small thickets of partially submerged willows and buttonbush, and accumulated logs and debris all provide a variety of microhabitats for benthos, epibenthos and fishes. The canopy of the larger trees and overhanging brush (primarily river birch) effectively shade much of the narrow stream and maintain low water temperatures. Lower water temperatures in turn allow for slightly higher levels of dissolved oxygen and for more of the stream to be utilized by fishes. The shading of the upper reach is especially vital during the warmer months, when much of the aquatic life is confined to relatively shallow pools.

(b) Bottom Composition.

The bottom composition as extrapolated from sampling of bottom sediments near Princeton Pike (Station 1) indicated a predominance of sand with equal proportions of silt and clay; detritus and gravel were minor components (Table VI-1). Visual inspection of the channel during low flows, however, indicated a somewaht altered bottom composition. Small areas of predominantly sand and gravel were evident, particularly in the upper portions, as were areas of accumulated detritus. In the Spring, portions of the channel were scoured to its hard clay base. This hardpan clay bottom was later covered with silt and organic debris.

(c) Plankton Communities.

Phyto- and zooplankton communities which are a vital part of the food web were poorly developed. Samplings of phytoplankton consisted of only a few genera of green and blue-green algae and the red-alga, Batrachospermum (Table D-1 appended). The zooplankton community was equally scant in diversity with only infrequent copepods, larvae, and nematodes (Table D-3 appended). The low plankton diversity may reflect the absence of direct sunlight, the slightly acidic character of the waters and the adverse effects of streamflow as well as possible sampling inadequacies.

(d) Benthic Communities.

The benthic communities of upper Bartholomew exhibited high species diversity and low numbers of organisms (Figure VI-2, Table VI-2, Table D-5 appended). The April diversity index (3.25) was the highest recorded for any station in either sampling period (April or November). Both samplings included a number of predatory aquatic insect genera which are indicative of a healthy aquatic system (Bartsch and Ingram, 1959).

The diversity index and biomass of the benthos decreased between April and November, whereas the absolute number of organisms per square meter increased. These seasonal changes reflect a combination of changes in streamflow, substrate and taxonomic composition between the two sampling periods; the effects of urban or agricultural activity appear to be minimal. During the spring, higher flow rates removed most of the silt deposits in the

channel and exposed large areas of detritus. The detritus created favorable habitat for large numbers of midge larvae (chironomids) which dominated the spring sample. Dragonfly, damselfly and mayfly nymphs were also relatively common and accounted for much of the biomass. In the absence of large silt deposits and in the presence of predatory insect nymphs, aquatic worms were a minor spring benthic component. With the deposition of silt over the summer months, and the emergence of predatory midge larvae and dragonfly, damselfly and mayfly nymphs, oligochates and fairy shrimp (Branchinecta sp.) became dominant in the fall. Siltation also may have reduced the availability of niches and, together with the hatching of the larger aquatic nymphs, reduced the fall diversity index and biomass values. Additionally, certain organisms (mayflies) may have been inhibited in their return to large population numbers by low concentrations of dissolved oxygen in July, August and part of October. Observed daytime readings during the summer months indicated dissolved oxygen levels of 0.1 to 0.4 mg/l.

(e) Epibenthic Communities.

Upper Bayou Bartholomew at Princeton Pike was extremely low in collected epibenthos in April due to high water and flow. The November sampling was dominated by chironomid larvae (Dicrotendipes sp.) from submerged logs with smaller numbers of grass shrimp, (Palaemonetes kadiakensis); scuds (Hyalella azteca) and immature crayfish (Table D-14 appended). Lack of extensive aquatic vegetation such as alligatorweed may have been the major factor in limiting the numbers of epibenthos collected. Although unaccounted for in the epibenthic samples, large numbers of crayfishes were encountered during fish seining efforts and represent a food source for many of the reptiles, amphibians and large predatory fishes.

(f) Fish Communities.

Twenty-eight species of fishes were collected (Table D-23 appended). This indicated a diverse and balanced fish community with an abundance of predatory and game species. Many of the species collected are indicative of relatively clear, slow-moving waters. Red-finned shiners (Notropis umbratilas), an important source of food for larger predators, were the most abundant fishes collected. They inhabit deeper clear water pools and are intolerant of excessive turbidity. The spotted sucker (Minytrema melanops), especially intolerant to turbid waters and industrial pollutants (Cross, 1967), was collected in abundance only in upper Bartholomew, where it inhabits the shallow pools with firm bottoms. The red-finned darter (Etheostoma whipplei), only found in the upper Bartholomew samples, is also indicative of clear, pollution-free waters and thrives in small sand-gravel riffle areas. Other common, but less restricted species, included the warmouth (Lepomis gulosus), the bluegill (L. macrochirus), the longear sunfish (L. megalotus), the green sunfish (L. cyanellus), and the dollar sunfish (L. marginatus). These sunfishes are most common near overhanging banks and brush. The flyer (Centrarchus macropterus) and banded pygmy sunfish (Elassoma zonatum) were also common, inhabiting the pool areas.

The balance of the fish community is probably due to the sparsity of vegetation and the excess of snags and submerged logs in this relatively clear, well-shaded, unchannelized portion of Bayou Bartholomew. Aquatic insects and other invertebrates are readily available to the fishes.

The smaller insectivorous and omnivorous fishes are also not protected from predators by dense vegetation; hence, the aquatic biosystem is balanced and stable.

(g) Aquatic-Oriented Reptiles and Amphibians.

The upper reach of Bayou Bartholomew, in the absence of extensive backwater and ponding areas, marshy habitats, and year-round flows, shows much less diversity in aquatic-oriented reptiles and amphibians than do the lower reaches of both Caney Bayou and Bayou Bartholomew.

Turtles prevalent in the upper reaches included the stinkpot (*Sternotherus odoratus*), living in the shallow pools and often basking in the slender river birches overhanging the stream; the razor-backed musk turtle (*Sternotherus carinatus*), similar in habitat to the stinkpot; the Ouachita map turtle (*Graptemys pseudogeographica ouachitensis*); the western chicken turtle (*Deirochelys reticularia miaria*), inhabiting quiet waters and often found on the banks; and the smooth softshell (*Trionyx muticus*), which buries itself in mud or sand and may bask on the banks near more permanent pools to which it can readily retreat.

Snakes common to the upper reaches of Bayou Bartholomew include the eastern hognose snake (*Heterodon platyrhinos*) which is a land dweller, but which feeds on small fishes and frogs, and several species of watersnakes (*Natrix* spp.) the most commonly encountered of which was Graham's water snake (*Natrix grahami*) which prefers the muddy banks of smaller water courses. The eastern garter snake (*Thamnophis sirtalis sirtalis*) can also be considered aquatic-oriented as it feeds on fishes and amphibians.

All salamanders require moist to wet habitats and can be associated with the bayou throughout its length. Those having aquatic larval stages or are aquatic as adults are closely tied to permanent waters. Those of the latter group common to the upper reach of Bayou Bartholomew include the three-toed amphiuma (*Amphiuma means tridactylum*) which inhabits the bottom sediment and debris, and the central newt (*Notophthalmus viridescens louisianensis*) which is also a bottom dweller.

Common toads and frogs closely associated with the waters of the upper reach include the dwarf American toad (*Bufo americanus charlesmithi*) which breeds in the shallow waters and smaller pools; the northern cricket frog (*Acris crepitans*) which is common in shallow water that provides cover with vegetation such as willows; and the southern leopard frog (*Rana pipiens sphenocephala*).

(h) Aquatic-Oriented Birds.

Due to the smallness of the channel, the absence of extensive backwater areas, and the limited area of floodplain, the upper Bartholomew streamreach supports a much less varied array of aquatic-oriented birds than the lower reaches. Of the wading birds, only the green heron (*Butorides virescens*) and the yellow-crowned night heron (*Nyctanassa violacea*) may occur as infrequent summer residents inhabiting highly protected shallow water areas. The wood duck (*Aix sponsa*) nests in large snags in and adjacent to the bayou. The belted kingfisher (*Megaceryle alcyon*) is infrequent but may nest in the upper reaches.

Some species which have become associated with upper Bayou Bartholomew were once distributed throughout the study area, but, with destruction and development of habitat elsewhere, are increasingly associated with areas such as upper Bartholomew where habitat remains. Examples include the wood thrush (Hylocichla mustelina), the hermit thrush (Catharus guttatus), the yellow-billed cuckoo (Coccyzus americanus) and several species of hawks, owls and woodpeckers

Many passerine or perching birds can be observed along upper Bartholomew. Some typical species include: the eastern phoebe (Sayornis phoebe) and the white-throated sparrow, common winter residents; the tufted titmouse (Parus bicolor), a permanent resident; the red-eyed vireo (Vireo olivacceus) and the yellow-throated warbler (Dendroica dominica), summer residents.

(i) Aquatic-Oriented Mammals.

The most conspicuous aquatic-oriented mammal at Station 1 and its streamreach is the beaver (Castor canadensis) which builds its home and dams with the abundant river birches and black willows. The raccoon (Procyon lotor), which feeds naturally along all water courses, is common but less so than in the downstream bottomland hardwoods. Other aquatic-oriented mammals which may be present include the muskrat (Ondatra zibethicus), the mink (Mustela vison) and the river otter (Lutra canadensis). The latter two species are probably only infrequent residents of the upper reach.

(2) Station 2 and Its Streamreach.

Interceptor Canal is a straight artificial drainage course which drains the western sections of Pine Bluff. The monitoring and sampling station was located near 34th Street (Figure VI-1). Almost all of the reach lies within the City of Pine Bluff. Residential development is the predominant land use. The channel is relatively homogeneous throughout providing little physical diversity. It is bounded by steep unprotected embankments which slough and erode severely during heavy rainstorms. The lower reach with recent channel improvements has no streamside or channel vegetation to provide bank stablization, shade or habitats. In the upper reach, however, there are small willows and cattails. Baseflow is meager during all seasons; baseflow water quality is generally good with dissolved oxygen levels relatively high during all seasons (see Appendix C). Storm events bring about a rapid increase in flow and provide severe shock loadings of sediment eroded from the banks and domestic wastes from the urban drainage areas. The absence of physical diversity, the scarcity of aquatic vegetation and the high flows and sediment loads of stormwaters are the major factors limiting the biological diversity of Interceptor Canal.

(a) Bottom Composition.

Sand is predominant at Interceptor Canal (Station 2), with smaller amounts of an allochthonous, nodule-like material of unknown origin.

Much of the sand is probably carried from the exposed banks into the canal during storm events. In general, the bottom composition of Interceptor Canal can be characterized as unstable and can support only relatively few bottom dwelling species.

(b) Plankton.

Despite the relatively good baseflow water quality and the absence of shading, the plankton communities at the time of sampling were poorly developed. This is probably attributable to the frequent flushing of the channel during storm events and excessive turbities. In phytoplankton, only moderate numbers of Spirogyra and diatoms were collected (Table D-1 appended). Spirogyra is a green alga often associated with eutrophic conditions. Among the zooplanktonic groups, rotifers and copepods were infrequently taken (Table D-3 appended).

(c) Benthic Communities.

The benthic community of Interceptor Canal was indicative of a moderately to severely degraded aquatic environment. Diversity indices were low and numbers of individuals high (Figure VI-2, Table VI-2). The major physicochemical factors controlling the benthic community structure appeared to be domestic sewage contributions during and after moderate and heavy rainfalls, the severe siltation problem occurring during rainfall and the unstable bottom composition. During the spring, the benthic community was dominated by larger aquatic worms (Lumbriculus sp. and Dero sp.), sludgeworms (Limnodrilus sp.) and a variety of dipteran larvae (Table D-6 appended). Limnodrilus sp., and to a lesser extent Lumbriculus sp. and Dero sp., are especially well adapted to sediment and moderate sewage pollution. The fall sample had a significantly lower diversity index, biomass, and number of individuals per square meter.

The fall community was dominated by small sludgeworms, by Limnodrilus sp. and to a lesser extent by the aquatic worm Dero sp. The marked change in the fall benthic community can be attributed to the channelization of the canal in June, 1974, which destroyed most of the existing community. With a loss of all aquatic vegetation and with increased sediment loads through the erosion of the denuded banks, it is apparent that only the most adaptable organisms survived.

(d) Epibenthos.

Interceptor Canal contained relatively few epibenthic invertebrates in both sampling periods (Table D-15 appended). Both the April and November samples were dominated by relatively few larval insects. The lack of epibenthos is probably also attributable to heavy silt loads in the water during and following storm events and to the absence of aquatic vegetation and other micro-habitats.

(e) Fish Communities.

No effort was made to collect fishes at Interceptor Canal (Station 2) except to collect predatory and herbivorous fishes for the pesticides and heavy metals survey (Section IV.C). The only species noted were

green sunfish, mosquitofish (Gambusia affinis) and golden shiners (Notemigonus crysoleucas). Only mosquitofishes were common. These species, especially green sunfish, are relatively tolerant of turbid and unstable conditions (Beadles, 1970).

(f) Aquatic-Oriented Reptiles and Amphibians.

Along the lower reach of Interceptor Canal, the absence of vegetation, the frequent flushing by storm events, and the absence of shallow pools provide little favorable habitat for reptiles or amphibians. In this reach, the three-toed amphiuma is probably the predominant amphibian. In the upper portions of the canal, where cattails and willows are present, there is favorable habitat for the Mississippi mud turtle, the skinkpot turtle, the western mud snake, the spotted salamander, the tiger salamander, the American toad, and a variety of tree and cricket frogs.

(g) Aquatic-Oriented Birds.

With the absence of extensive vegetation and with land use dominated by urban development, there is little aquatic-oriented bird diversity along Interceptor Canal. Barn swallows (Hirundo rustica) nest under bridges, rough-winged swallows (Stelgidopteryx ruficollir) nest in the banks and the Mississippi kite (Ictinia mississippiensis) forages over the canal. Where cattails and willows are well developed, the red-winged blackbird (Agelaius phoeniceus), and a variety of sparrows may be seen.

(h) Aquatic-Oriented Mammals.

The overall aquatic habitat of Interceptor Canal is seemingly unfavorable habitat for the residency of aquatic-oriented mammals. The racoon, which is abundant throughout the Study Area, undoubtedly forages along the more isolated sections of the canal.

(3) Station 3 and Its Streamreach.

Station 3 and its associated streamreach extends from Shannon Road to Highway 15 downstream. The sampling and water quality monitoring station was at Highway 15 (Figure VI-I). This reach is a heterogeneous segment of the bayou and difficult to characterize. It lies on or near the escarpment of the Coastal and Alluvial plains and begins to widen and meander over a well defined floodplain. It retains some of the characteristics of the upper reach, particularly above the confluence of Nevins Creek, a major tributary entering from the southwest. Backwater areas are common, but not extensive. Of the three reaches of Bayou Bartholomew, "middle Bartholomew" is the most decidedly influenced by urban development. Not only does it receive the sediment rich effluent of Interceptor Canal, but much of the bottomland forests of its floodplain have been cleared for pastureland and urban growth. This has a significant adverse impact on all aquatic communities. Two small portions of the middle reach have been channelized, which further diminishes the habitat potential.

The habitats of middle Bartholomew are varied and discontinuous. Portions of the stream retain some of the original configuration and streamside vegetation (i.e., west of Highway 15 and scattered small segments upstream

from Hazel Street). Some of the more common overstory species shading and providing habitat in these segments include: water oak (Quercus phellos), sweetgum, sugarberry (Celtis laevigata), sycamore (Platinus occidentalis) and buttonbush. In the cleared or partially cleared areas, rosemallow (Hibiscus militaris) and buttonbush predominate but offer little in the form of shade or habitat. Along the channelized portions (south of Shannon Road and Interceptor Canal) black willow is dominant. Floating vegetation consists of mats of alligatorweed which are common, but not extensive, and which create some habitat for epibenthos and small fish communities. Generally, middle Bartholomew is less shaded than other reaches as evidenced by a mean annual water temperature of 17.2$^{o}$C at Station 3 as opposed to 14.9$^{o}$C at Station 1. The overall water quality of middle Bartholomew is fair with storm generated sediment, urban and rural sanitary wastes and periodic low levels of dissolved oxygen being the most conspicuous problems. The introduction of silt creates a shifting silty bottom throughout most of the reach.

The combination of silt, unstable bottom substrates, the loss of streamside vegetation and channelization are the salient limiting factors to biological diversity. Benthic invertebrates are slightly less diverse than upstream, the fisheries are best characterized as inbalanced and the aquatic-oriented herpetofauna, birds and mammals are depleted or altered in composition.

(a) Bottom Composition.

The bottom composition of Bayou Bartholomew at Highway 15 (Station 3) is unstable and consists primarily of hard clays in mid-channel and of mostly silt near shore, reflecting mid-channel scouring and shoreline deposition. It is neither heterogeneous or stable enough to support well diversified benthic and fish populations.

(b) Plankton.

With significant silt loads, the phytoplankton community was exceptionally poorly developed at the sampling period. Diatoms and the blue-green alga Oscillatoria were only infrequent components (Table D-1 appended); zooplankton was also sparse (Table D-3 appended).

(c) Benthic Communities.

Middle Bayou Bartholomew at Highway 15 has a relatively healthy benthic community with diversity indices of both sampling periods near 3.0 (Table VI-2). The sludgeworm Limnodrilus and the leech Helobdella lineata were co-dominants in both sampling periods and indicative of moderate pollution with some dissolved oxygen stress (Table D-7 appended). These species also typically occur where the bottom is periodically covered with silt. In addition, the spring and fall samples had representatives of several dipteran larvae. In the fall, several chironomid genera replaced those which dominated the spring sampling, probably as a result of seasonal and habitat changes. Diversity, biomass and numbers of organisms were all somewhat less during fall, perhaps attributable to the emergence of chironomid larvae and the increased deposition of silt out-washing from Interceptor Canal and upstream construction projects. Overall, the benthic community indicates some influence of the urban area, notably sewage and silt contributions. However, these contributions are of

insufficient strength to severely restrict species diversity. Limitations to benthic habitats appear to be mainly due to substrate changes, apparently as a result of localized sediment distribution.

(d) Epibenthic Communities.

Bayou Bartholomew at Highway 15 had relatively moderate numbers of epibenthos (Table D-16 appended), despite vegetation consisting of duckweeds (*Spirodela* spp. and *Lemna* spp.) and mats of alligatorweed. This vegetation provided habitat for large numbers of grass shrimp which dominated both samplings. With the relatively high benthic diversity index, the moderately good water quality and the abundance of grass shrimp in this reach, predatory fish populations could be expected to flourish.

(e) Fish Communities.

Seine collections were made both in the littoral areas of the stream and in a flooded ditch area north of the bayou and adjacent to Highway 15. Bluegills (*Lepomis macrochirus*) were the most numerous game fishes; gizzard shads (*Dorosoma cepedianum*), mosquitofishes, and weed shiners (*Notropis texanus*) were the most common non-game fish species.

Composition of fishes changed from stations 1 to 3 (Tables D-23 and D-24 appended), with the addition of several species with lentic-type habitat preferences (golden topminnow, *Fundulus chrysotus* and brook silverside, *Labidesthes sicculus*) and preferences for weedy habitats (mosquitofish; weed shiners; starhead topminnow, *Fundulus notti* and orange spotted sunfish, *Lepomis humilus*). Gizzard shad increased in abundance and size downstream. This can be attributed to the larger channel size and slightly greater abundance of plankton at Station 3. Certain fishes such as spotted suckers (*Minytrema melanops*), creek chub suckers (*Erimyzon oblongus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*) and redfin shiners (*Notropis umbratilis*) were collected at Station 1, but not at Station 3. Absence of these fishes may be attributed to increased silt loads, sampling differences, lack of shaded pools, fewer snags and submerged logs.

Juvenile bowfin (*Amia calva*) were collected downstream from Station 3 in a flooded backwater area near the Hazel Street bridge. Although this was the only study collection of bowfin in the entire Study Area, it is likely to occur in similar backwater areas.

Although seine catch per unit effort was similar to the upper reach, the sample population was imbalanced by mosquitofish, weedshiners and immature bluegills. Weedy habitats, such as those noted at Station 3, offer these species protection and food. In spring and fall seine efforts, young-of-the-year bluegills predominated the sunfish populations. Although larger bluegills probably evaded the seines more successfully than the smaller ones, these results indicated a population imbalance. The alligatorweed offers the young bluegills considerable protection from largemouth bass and crappie. Because bluegills in crowded populations will nourish themselves on eggs from other fishes, including bass, this imbalance can be sustained for considerable periods of time. The epibenthos, notably grass shrimp, provide food for these carnivores and help sustain their numbers.

(f) Aquatic-Oriented Reptiles and Amphibians.

The Station 3 streamreach, with its heterogeneous streamside habitat, supports a variety of aquatic-oriented reptiles and amphibians. Limiting the diversity is the adsence of abundant snags and debris in the channel and the clearing of the streamside hardwoods. In the brushy, cutover backwater portions of the reach west of Highway 15, there has been an unconfirmed report of the American alligator. The individual alligator was probably a transient.

Among the turtles, the omnivorous common snapping turtle (Chelydra serpentina) can be found in the more permanent backwater areas such as encountered near Hazel Street. The southern painted turtle (Chrysemys picta dorsalis), the slider (C. concinna hieroglyphica), the Missouri slider (C. floridiana hoyi), the western chicken turtle and the razor-backed mud turtle are all common in the shallower areas with soft muddy bottoms.

The western cottonmouth (Agkistrodon piscivorus leucostoma) is present in small numbers. The western mudsnake (Farancia abacura reinwardti) is a common resident particularly in the backwater areas where it feeds on small frogs. Also within the backwater areas and occupying a variety of habitats are watersnakes of the genus Natrix.

Among the salamanders, both the three-toed amphiuma and the central newt are probably common in the soft muddy bottoms along this streamreach. Other common salamanders include the spotted salamander (Ambystoma maculatum), the Red River waterdog (Necturus maculosus louisianensis) and the slimy salamander (Plethodon glutinosus).

Frogs and toads associated with the middle reach include a variety of groups of which the American toad and the southern leopard frog are probably the most abundant. In the quiet areas, the bronze frog (Rana clamitans) and the bullfrog (Rana catesbeiana) are also common. Throughout the moist vegetated segments a variety of tree, cricket and chorus frogs can be found.

(g) Aquatic-Oriented Birds.

The middle reach of Bayou Bartholomew offers a variety of bottomland habitats to birds, including streams edge and seasonally flooded bottomland forest. However, with increasing clearing and draining of the floodplain hardwoods, there has been a decline of aquatic-oriented birds in this reach which has been documented by the Jefferson Audubon Society. Among wading birds, the green heron is typical of the stream edges and nests in this reach, and the rare least bittern (Ixobrychus exilis) has been recorded here. The great blue heron (Ardea herodias)is occasionally seen and the little blue heron (Florida caerulea) may be seen in the spring foraging for crayfish in wet fields. Both species prefer the more isolated reaches. The yellow-crowned night heron is sometimes seen foraging in shallow water areas in this reach. The wood duck is a relatively common permanent resident which nests in the forested stretches. The belted kingfisher is a conspicuous permanent resident sometimes seen perched over the stream, fishing. The bottomland forest along this segment hosts thrushes, hawks, owls and woopeckers which formerly occured widely over the study area but have now become more limited in distribution as their bottomland hardwood habitat elsewhere has been cleared.

Among the passerines, all of the species noted for the upper reach would be common or abundant along middle Bartholomew. Most of the 170 species listed in table D-29 as occuring along Bayou Bartholomew might be found in this segment. In fact, one person, Marie P. Locke, has compiled an individual list of 146 species within one mile of the bayou in this reach. The reach is an important stopover for many warblers, thrushes and flycatchers during migration. with unusual species such as blue-winged warbler (Vermivora pinus), graycheeked thrush (Catharus minimus) and yellow-bellied flycatcher (Empidonax flavientris) sometimes seen. During the summer, the acadian flycatcher (Empidonax virescens) may be found nesting in the bottomland hardwoods and the rough-winged swallow breeds in the banks, particularly in the channelized section. The white-eyed vireo (Vireo griseus) breeds in the brushy backwater areas between Hazel and Olive streets and the northern parula warbler (Parula americana) is common in the bottomland forest along the watercourse. During the winter, the reach supports a large variety of sparrows, including the uncommon LeConte's sparrow (Ammospiza lecontii) and tree sparrow (Spizella arborea).

(h) Aquatic-Oriented Mammals.

The beaver, muskrat and nutria (Myocastor coypus) are the common aquatic-oriented mammals and are more tolerant to disturbed habitats and urban encroachment. The river otter and mink are probably somewhat less common.

(4) Station 4 and Its Streamreach.

Outlet Canal is an artificial drainage canal which drains the eastern portions of Pine Bluff and empties into Bayou Bartholomew. The sampling and water quality monitoring station was located at 38th Street (Figure VI-1). Although it drains the City of Pine Bluff, much of the canal lies adjacent to small woodlots, croplands and wasteland. Flows are minimal during baseflow, but discharge increase rapidly during storm events quickly flushing most of the system. The narrow, straight channel is lined and often clogged with cattails and willows which provide potential habitat. Sugarberry, sweetgum and willow oak are infrequent overstory species which shade some segments. Despite the vegetational components and the potential habitats they provide, Outlet Canal is severely limited by its water quality and supports few aquatic-oriented organisms.

Both baseflow and stormwaters are rich in organics and nutrients and low dissolved oxygen levels are chronic. During storm events silt loads are relatively high.

(a) Bottom Composition.

The bottom composition of Outlet Canal appeared to be enriched organically, with an oozy silt throughout. Sand and silt make up about 80 per cent of the bottom sediment at this station (Table VI-1). Substrate materials appeared relatively homogeneous across the stream transect and supported large numbers of sludgeworms and fingernail clams.

(b) Plankton Communities.

Outlet Canal supported a variety of phytoplankton species (Table D-1 appended) when compared to those of other stream stations; the green alga Closterium was common. This alga is generally not associated with polluted conditions as noted at Station 4. The zooplankton component was almost non-existent and was represented by infrequent nauplii and rotifers (Table D-3 appended).

(c) Benthic Communities.

The diversity indices of Outlet Canal were the lowest recorded for all sampling stations and indicated a severely degraded aquatic system (Table VI-2). The sludgeworm (*Limnodrilus* sp.) and the fingernail clam (*Sphaerium transversum*) were the dominant organisms and together accounted for 99 and 96 per cent of the total number of individuals per square meter in April and November, respectively (Table D-8 appended). Both of the dominant organisms occurred in extremely large numbers and (Table VI-2) reflect a dominance of sanitary wastes in Outlet Canal. Large organic and nutrient loads, an unstable ooze-like substrate, and low dissolved oxygen levels all combined to severely restrict biological habitats in this canal. Sludgeworms and fingernail clams unexplainably decreased significantly in number between April and November. The sludgworm can reduce BOD loads of the mud it ingests by as much as one-half (Bartsch and Ingram, 1959). By its presence in large numbers this oligochaete may act as one of the early biological balances in the canal's recovery. Numerous leeches noted in the spring and fall samples are also indicative of polluted conditions.

(d) Epibenthic Communities.

Despite the pollution load of Outlet Canal, epibenthos were relatively diverse and numerous (Table VI-3) responding primarily to the abundance of vegetation. Grass shrimp was the most abundant organism in April; snails of the genus *Physa*, in November (Table D-17 appended). The presence of the snail *Physa*, however, indicates organically rich waters frequently experiencing dissolved oxygen stress (Beck, 1954). Leeches were minor components of both samplings; their presence indicates moderate pollution.

(e) Fish Communities.

Fishes were collected at Outlet Canal for heavy metals and pesticide analyses only. Pirate perch (*Aphredoderus sayanus*) and mosquitofish were most common, with smaller numbers of orangespotted sunfish and golden shiners. All of the orangespotted sunfish were small. Considering the organic enrichment and the dissolved oxygen deficiency, the larger fishes of this species either spawned in the canal and migrated back to Bayou Bartholomew or entered with the smaller fishes and either migrated or perished. Smaller fishes, because of a larger gill surface to body weight ratio, can tolerate lower dissolved oxygen conditions better than larger fishes of the same species. All of the above species prefer quiet, weedy waters, which Station 4 affords. Both mosquitofish and pirate perch are tolerant of low dissolved oxygen and organically enriched areas.

(f) Aquatic-Oriented Reptiles and Amphibians.

Common aquatic-oriented reptiles and amphibians of Outlet Canal include: the common snapping turtle, softshell turtles (*Trionyx* spp.), the Mississippi map turtle, the western mud snake, water snakes (*Natrix* spp.), the three-toed amphiuma, the leopard frog and the American toad. Numerous chorus and cricket frogs are probably also common. With abundant vegetation, the diversity of amphibians could be high; however, they would be limited by the frequent flushing of the system during storm events and the absence of physical diversity in the habitat (pools, small backwater areas, etc.).

(g) Aquatic-Oriented Birds.

The limited aquatic-oriented bird life of Outlet Canal is primarily made up of passerine species associated with the abundant cattails and brush of the streambank. With the high numbers of benthos and the canal's relative isolation from the urban area, wading birds such as the green heron and yellow-crowned night heron may be seen foraging occasionally. Sparrows and red-winged blackbirds are the most common passerines of the canal.

(h) Aquatic-Oriented Mammals.

The raccoon is probably the only common mammal associated with Outlet Canal, although muskrat and nutria could possibly be found utilizing the abundant vegetation.

(5) Station 5 and Its Streamreach.

The lower reach of Bayou Bartholomew is delineated from Highway 15 southeastward to the limits of the Study Area. The sampling and water quality monitoring station was located near Pinebergen (Figure VI-1). The lower reach is characterized by a widened, baldcypress-lined channel with numerous backwater areas. The bayou below Highway 15 enters the Quaternary Alluvium, with its flat to gently undulating topography whose major usage is as an agricultural area. Croplands comprise about 20 per cent of all land use below Highway 15, with about 16 per cent urban and over 50 per cent forested lands in the same watershed area. Land use in the Station 5 streamreach is thus modified from primarily forested and cleared upstream usages to forested, agricultural and urban usages. However, while much of the urban stormwater runoff enters the bayou directly, much of the agricultural runoff is apparently detained by Bayou Imbeau and other watersheds. Vegetation at this station and along the entire lower reach of the bayou consists primarily of baldcypress and abundant cypress snags with buttonbush and switch cane also common. Baldcypress and several large hardwoods help to stabilize the banks and provide shade and cover for birds, herpetofauna, fishes and invertebrates and modify flows during high water periods. Aquatic vegetation such as duckweeds and alligatorweed provide cover for invertebrates and food for various species.

The water quality at Station 5 is generally good and does not appear to be limiting to biological productivity. The benthic communities, however, were less diverse than anticipated and may reflect unobserved water quality problems.

The diversity of lower Bayou Bartholomew rests largely in its ample and mature streamside vegetation, the abundance of snags and debris in the channel, its isolation and its good water quality. Limitations such as moderate siltation and the extensive clearing of adjacent bottomland hardwoods destroy the requisite continuity of habitat for many aquatic-oriented species.

(a) Bottom Composition.

The substrate at Station 5 is similar to that of Station 1, with sand predominant (Table VI-1). Scoured areas of hardpan clay are less

common, and more of the stream bottom appears covered with homogeneous silt and organic matter. Because of the substrate differences, aquatic worms are more numerous here than upstream, including the pollution-indicating sludgeworm.

(b) Plankton Communities.

Both phyto- and zooplankton communities were rather poorly developed at the sampling times (Tables D-1 and D-3 appended). Diatoms were dominant but infrequent. Cladocerans and rotifers were the major zooplankton groups. The scarcity of plankton at Station 5 reflects flow conditions, shading and turbidity.

(c) Benthic Communities.

The diversity indicies recorded for lower Bayou Bartholomew at Station 5 were relatively low (Table VI-2) and suggest an absence of habitat diversity; the high numbers of individuals particularly in the spring sampling period indicate a degree of organic enrichment. The sludgeworm was the dominant organism during sampling periods and its abundance also suggests organic enrichment as well as dissolved oxygen stress and an unstable silt substrate. Other common benthic macroinvertebrates included the aquatic worm Dero, mayfly nymphs (Hexagenia), dipteran larvae (Tanypus and Cryptochironomus) and the fingernail clam (Sphaerium) in the spring and a variety of oligochaete worms (Naididae, Pristina and Ophidonais) and fairy shrimp in the fall (Table D-9 appended). Between April and November Station 5 appeared to have a more balanced benthic community with an increase in biomass and the number of individuals per square meter. Despite the November sampling being located approximately 50 meters downstream from the spring sampling station and away from bridge rubbish and trash, no explanation can be offered to account for these changes. A comparison with upstream Station 3 shows Station 5 to have a similar to improved water quality (Section IV.B.),but lower benthic macroinvertebrate diversity than the upstream site. Possibly this diversity is affected by agricultural toxins applied near Station 5 (Section IV.C.), or by some unmonitored influence.

(d) Epibenthic Communities.

In April, only a few epibenthic forms were collected from lower Bartholomew at Station 5. In November, 76 individuals were collected. (Table D-18 appended). The sample was dominated by grass shrimp and water boatmen (Notonectidae). Vegetation was similar to that at Station 3, but not as dense. Stands of baldcypress were also prevalent along the stream at Station 5. It appears that the limitations to benthic diversity were not reflected in the epibenthic forms. Aquatic vegetation appears more likely to be a limiting factor for epibenthos at the stations on Bayou Bartholomew, than do inorganic and organic nutrient contributions from urban and non-urban sources.

(e) Fish Communities.

Seine and rotenone efforts in lower Bartholomew at Station 5 were hindered by high water and a lack of shallow pools. Bluegills and pirate perch accounted for approximately one-fourth of the total game and nongame fish biomass (Table D-25 appended).

Game species were predominantly sunfish; no largemouth bass or crappie were taken, although the habitat appears favorable for them. Although most sunfishes were one year old or younger, less imbalance within this family was noted than at Station 3. This may have been due to a sparcity of alligatorweed at Station 5.

Darters, which are indicative of relatively clean water were commonly collected. The other common non-game fishes were yellow bullheads (Ictalurus natalis), tadpole madtoms (Noturus gyrinus), mosquitofish and pirate perch. The high numbers of tadpole madtoms at this site may have been enhanced by litter thrown from an upstream bridge, as they have been reported to utilize foreign objects as nest sites (Cross, 1967).

A total of 30 fish species were collected at Station 5, two more species than obtained at Station 1. This increase in diversity is not unusual, as Odum (1971) has noted that the number of species found in the headwaters of a small stream is usually less than that found in the downstream area.

The problems associated with upstream pollution sources (Interceptor and Outlet canals and agricultural activities) are not evidenced by fish populations at Station 5. Although plankton feeders are more numerous, their presence may be due equally to physical changes in the stream (channel enlargement, decreased shading, etc.) rather than to nutrient enrichment and subsequent algal blooms. It appears that Bayou Bartholomew and its associated floodplains assimilate a considerable proportion of the solids, minerals and nutrients contributed from upstream sources, especially by the time the loads reach Station 5.

(f) Aquatic-Oriented Reptiles and Amphibians.

All of the aquatic-oriented species of reptiles and amphibians enumerated for the Station 3 streamreach probably also occur in the lower segment. Among the turtles, the omnivorous common snapping turtle can be found anywhere along the lower reaches where backwaters are permanent. The southern painted turtle, the slider, the Missouri slider and the red-eared turtle (Pseudmys scripta elegans) are common throughout both lower reaches, where they live chiefly in shallow water areas with soft, muddy bottoms and profuse aquatic vegetation, and feed upon aquatic vegetation, insects, crawfish and small molluscs. Also along the lower reaches and commonly basking on stumps and snags is the Mississippi map turtle (Graptemys kohni), which prefers larger streams and lakes.

Among the snakes, the western cottonmouth is common in the lower reach and most frequently encountered near logs and other debris along the stream where it feeds on fishes, frogs, small birds and mammals. The western mudsnake is also a common resident, particularly in the backwater areas where it feeds on small frogs and amphibians. Also within the backwater areas and occupying a variety of niches are many members of the genus Natrix: the yellow-bellied watersnake (N. erythrogaster flavigaster), the green watersnake (N. cyclopion), the diamond-backed watersnake (N. rhombifera), the glossy watersnake (N. rigida), the broad-banded watersnake (N. sipedon confluens) and the midland watersnake (N. s. pleuralis).

Frogs and toads associated with the lower reach include the American toad and the southern leopard frog which are probably the most abundant. In the quiet areas where there is extensive vegetation, one could also expect to encounter the bronze frog and the bullfrog.

In the salamander group, both the three-toed amphiuma and the central newt of the upper reach would also be common throughout the lower portions of the bayou. In addition, other aquatic-oriented salamanders of the lower reach include the western lesser siren (Siren intermedia nettingi) and the Red River waterdog (Necturus maculosus louisianensis). Although the mole salamander (Ambystoma talpoideum) has not been collected in central Arkansas, it is a secretive burrowing salamander, and could possibly be found in the more remote backwater areas of the lower reaches of Bayou Bartholomew.

(g) Aquatic-Oriented Birds.

The lower reach of Bayou Bartholomew contains a variety of bird habitats: the wide stream channel itself; backwater areas; abundant tall snags; and a narrow strip of bottomland hardwood forest or brush bordered by agricultural fields which provide a great deal of edge habitat. Therefore many of the aquatic-oriented birds associated with middle and upper Bartholomew may be found here, along with a number of edge species. Because virtually all adjacent forest has been cleared, this strip along the bayou is heavily utilized as a stopover by migrants. Also, the presence of edge allows a thorough mixing of wetland, forest, edge and field species. Along lower Bartholomew, it is possible to simulataneously watch bobolinks (Dolichonyx oryzivorus), buntings, warblers, herons and hawks. The green heron is probably the most common wading bird, but the great blue heron and little blue heron thrive in the isolation afforded by this reach. The yellow-crowned night heron is less common here than along the middle reach, except in the extreme upper segment of the reach, where, on the north shore of Byrd Lake, 15 pairs nested until 1964. When that heronry was destroyed by timber harvest, the birds moved to the south shore of the lake (between the lake and Bayou Bartholomew), and seven pairs bred in that location in 1970. Their numbers have declined since then. In the more remote sections of the reach there have been occasional sightings of the northern bald eagle (Haliaeetus leucocephalus alascanus). Typically these large birds are seen perched in the large trees or cypress snags. Fish crows (Corvus ossifragus) are becoming increasingly common along this reach and the uncommon olive-sided flycatcher (Nuttallornis borealis) is occasionally seen during migration in the edge habitat. Vireos and warblers are also common and the prothonotary warbler (Protonotaria citea) is most abundant in the lower reaches where it nests frequently in old cypress snags. The snags and large baldcypress trees are unique elements to lower Bartholomew and provide important habitat for several other species: the common flicker (Colaptes auratus), the red-bellied woodpecker (Centurus carolinus), the red-headed woodpecker (Melanerpes erythrocephalus), the downy woodpecker (Dendrocopus pubescens) and the rarely sighted Bell's vireo (Vireo bellii). The edge habitat along the lower reach attracts the painted bunting (Passerina ciris) which, though not common, occurs in the study area almost exclusively along lower Bartholomew. This habitat is also favorable for nesting and roosting mourning doves (Zenaida macroura).

(h) Aquatic-Oriented Mammals.

Raccoons are abundant in the wet forested areas and beaver and muskrat are common along the lower reach of Bayou Bartholomew. Nutria probably occur in limited numbers along this streamreach. River otter and mink are also present but probably not common because of the extensive clearing of the adjacent bottomland hardwoods.

(6) Station 7 and Its Streamreach.

(a) Headwaters to Lake Pine Bluff.

Caney Bayou is a relatively short tributary of the Arkansas River; but like Bayou Bartholomew, it straddles the escarpment between the Coastal and Alluvial plains. Its upper reaches above Highway 65 are probably analagous to upper Bartholomew although no biological sampling or reconnaissance was conducted. The middle reach from Highway 65 to Lake Pine Bluff is highly disturbed with much of its segment channelized and receiving the effluent of both municipal and industrial oxidation ponds (Section IV.B.). In the disturbed segments much streambank vegetation has been removed and erosion is a serious problem. Unchannelized stream segments have a vegetational cover consisting primarily of black willow, buttonbush, sugarberry and elm with less abundant growths of lizard's tail (*Saururus cernuus*), cattail, rosemallow, and rushes (*Juncus* spp.). These plants provide habitat and cover for invertebrates, fishes, herpetofauna and some aquatic-oriented birds, and function as bank stabilizers and provide shade. Water quality as monitored at Station 7 indicates moderately degraded conditions when compared with upstream Station 6 data. Blooms of the blue-green alga *Oscillatoria* sp. are also indicative of somewhat polluted conditions. Moderate numbers of copepods and ostracods are supported by *Oscillatoria*, organic debris and bacteria along this streamreach and are, therefore, available to foraging, pelagic fishes such as golden shiners and gizzard shad. Both fishes were collected in abundance at Station 7, but are probably not abundant upstream nearer the oxidation pond effluents. Likewise, large predatory fishes such as the spotted gar occur at Station 7 but become less frequent upstream. Bottom sediments at Station 7, due to their silty, somewhat oozy nature, appear to be conducive to oligochaete populations. Sludgeworms were numerous but were balanced by populations of midge larvae, crayfish and scuds. The latter are indicative of moderately-polluted to relatively unpolluted conditions, and are of food value to sunfishes, amphibians and wading birds. Large numbers of epibenthos provide food for fishes and carnivorous herpetofauna at Station 7. Moderate growths of alligatorweed and duckweeds provide a degree of protection for area epibenthos; however, these invertebrates appear to be readily available as food to fishes and herpetofauna. Fishes at Station 7 and in near-upstream reaches can probably avoid seasonally prevalent anaerobic conditions by migrating downstream towards well-oxygenated Lake Langhofer. Fisheries habitat is generally poor along the entire Station 7 streamreach with the exceptions of the Lake Pine Bluff Spillway area and overflow areas above the University of Arkansas at Pine Bluff. Stream habitat for reptiles and amphibians is also limited by lack of snags, backwater areas and to a degree by poor water quality. Aquatic-oriented bird life is similarly limited along the middle reach.

1. Bottom Composition.

Bottom composition from Lower Caney Bayou (Station 7) appeared more silty in the field that the laboratory analysis indicated. Equivalent amounts of sand, silt and clay were noted (Table VI-1). Visual observations of dredged materials indicated a relatively homogeneous bottom.

2. Plankton Communities.

The blue-green alga *Oscillatoria* was abundant (Table D-1 appended). *Oscillatoria* is typically indicative of moderate organic pollution. Unlike other stream stations, the zooplankton community was well-developed with copepods, nauplii and ostracods frequent (Table D-3 appended). Each of these serve as important food sources for macroinvertebrates and fishes.

3. Benthic Communities.

Along middle Caney (Station 7) diversity indicies were relatively high and together with relatively low numbers of individuals indicated only a moderate pollutional load (Table VI-2). The sludgworm Limnodrilus and dipteran larvae (chironomids), both common indicators of moderate pollution, particularly that of sewage, were dominant in the spring sampling. In the fall these dominants were largely replaced by fairy shrimp, amphipods and different genera of dipteran larvae (Table D-1C appended), none of which are considered indicators of pollution. Although the diversity index essestially did not change between April and November, the numbers of individuals per square meter and biomass declined markedly (Table VI-2). The emergence of dipteran larvae can possibly explain some of the changes in taxonomic composition and the overall decline in organism numbers from spring to fall, but does not account for the decline of oligochaetes and the dominance of fall organisms such as amphipods, fingernail clams and fairy shrimp, except that the latter may have fed extensively on decaying organic matter.

Station 7 is located downstream from the effluents of both municipal and industrial oxidation ponds and is characterized by exceptionally high nutrients, particularly phosphates, relatively high organic concentrations and low dissolved oxygen levels (less than 1 mg/l) throughout much of the summer and fall. Low D.O. levels were noted at the downstream side of the bridge at this station; large amounts of trash, detritus and logs may have considerably reduced these levels from the upstream benthic sampling site. Dissolved oxygen levels measured at Station 7, therefore, may not be indicative of near-upstream conditions.

4. Epibenthic Communities.

The Station 7 streamreach contained the most diverse and dense populations of epibenthic forms of any Pine Bluff area station (Table VI-3). Vegetation consisted of lizard's tail, buttonbush, cattail, alligatorweed and duckweeds; these forms provided excellent habitat for grass shrimp which dominated both samplings (Table D-19 appended). Data from both epibenthic and benthic sampling indicate relatively stable populations of aquatic invertebrates despite known sources of wastes entering the bayou upstream (Section IV.B.). One explanation is that Caney Bayou at this point is in a "zone of recovery" from the Caney oxidation pond effluent upstream.

5. Fish Communities.

Caney Bayou near Lake Pine Bluff (Station 7) was sampled for fishes with rotenone only because the steep banks in this previously channelized portion of the stream made seining impossible.

A total of 23 fish species were collected (Table D-26 appended). There was a notable imbalance of carnivorous to herbivorous fishes. Almost one-third of the non-game species consisted mostly of longear sunfish and bluegills, with fewer warmouth, green sunfish, dollar sunfish, spotted sunfish (Lepomis punctatus), largemouth bass and black crappie. Several

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species indicative of lentic-type habits included spotted gar (Lepisosteus oculatus) and freshwater drum (Aplodinotus grunniens). As no darters were collected, it is assumed that substrate conditions were not suitable; lack of vegetal cover may also have been a limiting factor in darter distributions here. Presence of bullhead minnows (Pimephales vigilax), yellow bullheads, black bullheads (Ictalurus melas) and black crappie appear to indicate minimal adverse sedimentation and turbidity problems, as all have preferences for relatively clean water. Additionally, Douglas (1974) indicated that bullhead minnows are common in river drainages where natural waters have not been excessively polluted. The presence of large numbers of filter feeding fishes indicates a degree of organic enrichment.

The fishes were sampled during the early summer when anaerobic conditions were already being noted in the bottom of the water column, yet numbers and species do not indicate severe water quality conditions. Fishes in this area, however, could easily migrate downstream to Lake Langhofer if water quality conditions became stressful for long periods. Sizes of predatory fishes such as largemouth bass and black crappie were small; most of the individuals were apparently Year I or young-of-the-year. Adult crappie and bass may enter Caney Bayou to spawn, then migrate back into the well-oxygenated portions of Lake Langhofer. Most of the remaining individuals then are the smaller, less mobile and low-dissolved oxygen-tolerant members of the species.

### 6. Aquatic-Oriented Reptiles and Amphibians.

The middle reach of Caney Bayou, as it traverses both uplands and lowlands, has an array of aquatic-oriented reptiles and amphibians. Brush and debris are abundant in the channel. The reach is limited, however, by channelized and disturbed segments and degraded water quality. Most of the stream-oriented reptiles and amphibians enumerated for the upper and middle reaches of Bayou Bartholomew could be encountered in the middle reach of Caney Bayou. Common turtles include the common snapping turtle, the Mississippi mud turtles, sliders (Chrysemys spp.), the razor-backed mud turtle, and the softshell turtles (Trionyx spp).

The reach would also be attractive to various snakes; the more common of which include the western cottonmouth, the western mud snake and several species of watersnakes.

Among the salamanders, the three-toed amphiuma and the central newt would both be common and many species of frogs and toads would be encountered.

### 7. Aquatic-Oriented Birds.

Little is known about the birds of the Caney Bayou system. Though potentially of much interest, the bayou is difficult of access and consequently its birds have been little studied.

Upper Caney Bayou (headwaters to Highway 65) is analogous to upper Bayou Bartholomew, and the description of the bird life along upper Bartholomew (page VI-15) applies in essence to upper Caney. There is one main difference in the two reaches and that is that there has been less clearing along upper Caney. Therefore the birds of that reach may be expected to include both aquatic-oriented and forest species, whereas the populations of upper Bartholomew would contain more field species.

The middle reach of Caney Bayou (Highway 65 to Lake Pine Bluff) contains long stretches which have been channelized and cleared. There is probably a low species diversity along these ditches. Occasional sightings of green heron, yellow-crowned night heron, wood duck, kingfisher and fish crow might be expected, particularly during low flows when the bottom sediments are exposed. Passerine species, notably sparrows, are common along this reach where they thrive in the brushy vegetation.

It should be noted that some stretches of this reach have not been channelized or cleared, such as east of Jefferson Industrial Park, and these stretches potentially have highly diverse and interesting bird populations similar to those of the middle Bartholomew reach. Future study should be directed to this area.

8. Aquatic-Oriented Mammals.

As the area is generally disturbed, the raccoon is the only common aquatic-oriented mammal encountered. Muskrat, beaver and nutria may, however, be found occasionally.

(b) Lake Pine Bluff to Lake Langhofer Confluence.

The lower reach of Caney Bayou from Lake Pine Bluff to Lake Langhofer has extensive backwater areas which are wet during all seasons. Large snags and ample cover combine to provide favorable habitat for fishes, reptiles and amphibians and aquatic-oriented birds. Although no sampling or reconnaissance was conducted in this lower reach, the fish community would be expected to be well-balanced with larger numbers of game and predatory species. Among the reptiles and amphibians, all aquatic-oriented species affiliated with the middle and lower reaches of Bayou Bartholomew could be expected, including the American alligator, which has been reported from Blackdog Lake.

The composition of the bird population of this reach should be similar to that of lower Bartholomew with these exceptions: lower Caney has less edge habitat and a lower general level of habitat diversity; lower Caney is located closer to the heavily-used Arkansas River migration corridor; and lower Caney possesses more open water (Blackdog Lake and backwater from Lake Langhofer).

The lack of edge and the lower habitat diversity dictate that some lower Bartholomew species will be absent or in reduced numbers, such as warblers and painted buntings. The Arkansas River migration corridor should contribute additional species such as white pelican (Pelecanus erythrorhynchos), osprey (Pandion haliaetus) and others included in the Lake Pine Bluff and Lake Langhofer discussions. The increased open water of the lower Caney reach will lead to increased numbers of hooded merganser (Lophodytes cucullatus), pied-billed grebe (Podilymbus podiceps), and purple gallinule (Porphyrula martinica), among others.

(7) Station 9a and Lake Pine Bluff.

Lake Pine Bluff is an artificial 500-acre impoundment created from the old Arkansas River channel. The lake is relatively shallow and receives its waters from rainfall runoff and the discharge of Brumps Bayou, which empties into the southwest corner of the lake. Water quality is generally good, except near the Brumps confluence which functions as a catch basin for silt and high organic loads from the bayou. Dissolved oxygen levels are also chronically low in this area.

Much of the lake has dense stands of old snags which represent the remnants of the bottomland hardwoods along the river. These, together with the dense mats of alligatorweed in the Brumps Bayou-Lake Pine Bluff confluence, provide exceptionally valuable habitat for fisheries. The biological monitoring station was established in the confluence area and does not typify the lake as a whole. Despite the degraded water quality of Station 9a, the fisheries appears to be excellent.

Plankton productivity is high and provides the basis for high fish biomass levels in the confluence area. Additional food is available as epibenthos living near and upon the extensive alligatorweed. The pollution loads of the confluence area are high, however, as indicated by low benthic diversity. The diversity index, second lowest for the Study Area, was low due to extremely high numbers of sludgeworms and fingernail clams occurring in the soft, silty substrate of the confluence area.

These "pollution" organisms, plus the low dissolved oxygen levels noted at the mid-depth and bottom of the water column indicate a limitation to fish and life at this confluence.

Fishes stressed by low oxygenated conditions are free to migrate into Lake Pine Bluff. The lagoon and much of the lake itself also provide valuable habitat for many aquatic-oriented reptiles and amphibians, especially turtles, as well as valuable habitat for aquatic-oriented birds.

(a) Bottom Composition.

Lake Pine Bluff (Station 9a) was characterized by a bottom composition consisting of a relatively high per cent of detritus and rather equal contributions of sand, silt and clay. This station also had the highest per cent of sticks and twigs comprising the lake bottom (Table VI-1). Although this type of composition typically favors high benthic diversity, utilization of these micro-habitats is limited by heavy silt loads and periodic low levels of dissolved oxygen.

(b) Plankton Communities.

The phytoplankton community of Station 9a was dominated by the green alga *Pediastrum* and the blue-green alga *Microcystis* (Table D-1 appended). The latter may be indicative of polluted conditions if found in extremely high numbers. However, such was not the case at Station 9a, as *Pediastrum* and other green algae not indicative of polluted conditions appeared more commonly than did *Microcystis*.

Lake Station 9a was dominated by rotifers, cladocerans and copepods (Table D-3 appended). Rotifers were particularly abundant at Station 9a. Abundance of the three zooplankton groups at this lake station can be best attributed to the absence of running water, phytoplankton abundance and availability of organic matter. Zooplankton distribution and numbers are not apparently limited because of polluted conditions. Both phytoplankton and zooplankton form an important supportive base for the fisheries of Lake Pine Bluff.

(c) Benthic Communities.

Water quality analysis indicated relatively high levels of nutrients, organics and silt from Brumps Bayou and frequent low dissolved oxygen levels at Station 9a. During the summer and fall of 1974, Lake Pine Bluff was drawn down and water quality deteriorated even further. Anaerobic conditions were common during this period as silt from Brumps Bayou, ladened with nutrients and organics, was carried rapidly to all areas of the station. The benthic macroinvertebrate composition reflects the severely degraded water quality (Table D-11 appended). Oligochaetes (*Limnodrilus* and *Dero*) and midge larvae (*Chironomus*), all pollution indicators (particularly of domestic wastes), were dominant during both spring and fall. Leeches were also common during both sampling periods. The spring diversity index was low and numbers of individuals were high (Table VI-2). In the fall sampling following the drawdown, the diversity index dropped 60 per cent and was the lowest value recorded at any station; numbers of individuals increased 40 per cent. All of these factors suggest habitat degradation between spring and fall. This is undoubtedly attributable to the drawdown rather than to seasonality. Moreover, the benthic community at Station 9a probably reflects its location at the mouth of Brumps Bayou and does not reflect the benthic community structure within the lake as a whole.

(d) Epibenthic Communities.

Epibenthos in Lake Pine Bluff during April yielded only one epibenthic organism, a dragonfly nymph (Macromia sp.). Damselfly and dragonfly nymphs are somewhat tolerant of low-oxygenated waters. November collections yielded a total of 93 individuals, of which midge larvae were dominant (Table D-20 appended). Silt deposits and adsorbed nutrients possibly limit substrate habitats for benthic species at this station, but do not adversely affect epibenthic forms. Station 9a contained dense mats of alligatorweed with some black willow and buttonbush near shore. The oxygen released by the alligatorweed was sufficient to sustain aquatic organisms near the top of the water column.

(e) Fish Communities.

Data from the Arkansas Game and Fish Commission (pers. comm.) regarding rotenone sampling in September, 1973, were obtained for the southwest corner of Lake Pine Bluff in the Brumps Bayou confluence area (Station 9a). Sampling data from the 1974 rotenone samples near the Lake Pine Bluff Spillway, which is across the lake from Station 9a, were not used in this discussion because of the difficulty of comparing and assessing fisheries results with other limnological survey data, all of which were taken near Station 9a.

Common game fishes at Station 9a were largemouth bass, white crappie (Pomoxis annularis), black crappie, channel catfish (Ictalurus punctatus), bluegill, redear (Lepomis microlophus) and longear sunfishes and warmouth. Bluegill accounted for almost one-fourth of the total gamefish biomass at this station. Gizzard shad comprised 82.7 per cent of the total non-game fish biomass.

Despite the low benthic diversity noted at Station 9a, and the water quality problems encountered at Brumps Bayou during storm events, epibenthic invertebrates and fishes in the lagoon area do not indicate severely degraded conditions. In this lagoon area, as at Lower Caney Bayou, fishes can easily migrate out, if anaerobic conditions become severe.

(f) Aquatic-Oriented Reptiles and Amphibians.

The Brumps confluence area and the whole of Lake Pine Bluff provide important habitat for many aquatic-oriented reptiles and amphibians. Among the turtles, the common snapping turtle, the Mississippi mud turtle, the red-eared turtle and the stinkpot would all be common. The confluence area and other brushy areas could also support the less common alligator snapping turtle (Macroclemys temmincki).

The western cottonmouth snake would probably be an uncommon member of the lake community. Various species of watersnakes are common, feeding on small fishes and frogs. Typically the watersnakes would be most common along the brushy portions of the southern and western shores.

The three-toed amphiuma would be common near Station 9a and the spotted salamander and Red River waterdog would frequent the less disturbed

shorelines. Frogs and toads representing several genera common to the Study Area would also be common, particularly in the quiet shallow waters of the confluence. These form an important food base for many of the larger predatory fish, snakes and birds.

(g) Aquatic-Oriented Birds.

Lake Pine Bluff contains a variety of bird habitats: open water, dead snags, emergent vegetation along shallow borders and brushy or grassy shores. The open water attracts water birds such as american coot (*Fulica americana*), pied-billed grebe, american widgeon (*Anas americana*), and gadwall (*Anas strepera*). Osprey are regularly seen during migration perched on the dead snags. Purple martins use the dead snags for overnight roosting from spring until fall, at which time they gather in large numbers for their migration ot South America. Along shallow borders of the lake, sora (*Porzana carolina*) may be found in the spring and green herons, great blue herons and little blue herons are regularly seen. In late summer great egrets (*Casmerodius albus*) and little blue herons spend several weeks in pre-migration gathering in the shallow areas of the lake. Just before dusk in the winter, strings of great blue herons pass downriver behind Lake Pine Bluff, headed for an unknown roost. Longbilled marsh wren (*Telmatodytes palustris*) also occurs in the shallow border habitat. The brushy or grassy shores are seasonally occupied by house wren (*Troglodytes aedon*), common yellowthroat (*Geothlypis trichas*) and a variety of sparrows including song sparrow (*Melospiza melodia*), savannah sparrow (*Passerculus sandwichensis*) and Le Conte's sparrow. During drawdowns, large areas of mudflat are exposed, which provide habitat for shorebirds. During those times, the area occupied by emergent vegetation is increased and least bittern may be found.

(h) Aquatic-Oriented Mammals.

Because of the disturbed nature of the lakeshore, the raccoon and opossum would be the only common mammals associated with Lake Pine Bluff.

(8) Station 10b and Lake Langhofer.

A large artificial arm of the Arkansas River was created from a bend in the river. Most of its shoreline is undeveloped and it contains numerous secluded backwater areas lines with bottomland hardwoods and brush. Dominant species include water locust (*Gleditsia aquatica*), American elm (*Ulmus americana*), water hickory (*Carya aquatica*), willow oak (*Quercus phellos*), water oak (*Quercus nigra*), river birch and hackberry. Black willows are predominant in the more open and distrubed areas. This vegetation is critical to the aquatic communities of the lake and provides cover for spawning fishes, foraging areas for adult fishes, and nesting and foraging sites for aquatic-oriented reptiles, amphibians and birds. Along the lake, the most productive shoreline area is the western shore and the backwater areas of Boyd Point.

The water quality of Lake Langhofer is good, but highly influenced by the Arkansas River. At its southern end, Caney Bayou enters the lake and carries in a considerable load of sediment and nutrients. Although the bottom substrate is comprised almost entirely of sand, a soft oozy silt layer overlies the sand near the Caney confluence and supports a considerable number of sludgeworms. Chironomids and occasionally abundant phantom midges dominate the benthos. The former are generally indicative of moderate pollution and the latter are voracious feeders which occur throughout Arkansas in profundal zones (Miner *et al.*, 1967). Diversity indices also indicate only moderately polluted conditions. Lake benthos are subjected to seasonal oxygen depletion at the mud-water interface; such conditions are partially due to pollutants carried in from Caney Bayou and to the settleing of organic debris (including dead plankton) from the water column. Plankton productivity is high, supporting considerable numbers of pelagic filter feeders such as shad, several species of buffalofish and juvenile forms of many other species. The fishery appears

balanced and capable of high sustained production. The willows and buttonbush at the north end of the lake sustain low numbers of epibenthos which are only of limited value to the lake fishery. Alligatorweed at the south end probably supports considerably more epibenthos and acts as cover for small sunfishes.

(a) Bottom Composition.

Lake Langhofer (Station 10b) is characterized by a bottom sediment composition consisting of 84.4 per cent sand, the highest concentration of any constituent at any of the sampling stations (Table VI-1). The lake's high percentage of sand is probably due to its recent history as a main channel of the Arkansas River. Silt and clay together made up less than 15 per cent of the bottom composition. In the shallower areas this bottom type provides excellent spawning habitat for sunfishes, yellow bass (*Morone mississippiensis*) and other game species.

(b) Plankton Communities.

Phytoplankton was abundant and diversified in Lake Langhofer (Table D-1 appended). The green alga *Scenedesmus* and the blue-green algae *Anabaena* and *Merismopedia* were dominant forms. None of the groups were abundant at problem levels nor did they indicate severe organic enrichment. The phytoplankton community was well-balanced and typical of a mildly eutrophic oxbow lake of the southeast. The zooplankton community was dominated by cladocerans, rotifers and copepods (Table D-3 appended), important food sources for young fishes as well as adult filter feeders.

(c) Benthic Communities.

The diversity indices of Lake Langhofer were high and remained unchanged between April and November (Table VI-2, Table D-12 appended). This suggests a more stable community in which variations in composition are controlled more by the life histories of the component organisms than by variations in the physicochemical environment. Water chemistries at Station 10b were generally good, although anaerobic zones appeared frequently at the mud-water interface during the warmer months. There were also indications of some intrusion of domestic wastes. These findings are reflected in the dominance of the sludgeworm *Limnodrilus* in both the spring and fall samples. A variety of dipteran larvae were common in the spring, but in the fall the aquatic worm *Dero* and midge larvae were common and nearly co-dominant with *Limnodrilus*. In general, *Limnodrilus* was more common near the Caney Bayou confluence than across the lake near the tip of Boyd Point. This abundance indicates a significant contribution of sediment and organic matter from Caney Bayou to Lake Langhofer.

(d) Epibenthic Communities.

Epibenthos collected in vegetation and in the littoral zone at Boyd Point-Lake Langhofer remained similar in numbers of individuals during both April and November (Table VI-3, Table D-21 appended). Benthic diversity was equally stable between seasons. Grass shrimp dominated the spring sample; midge larvae, the November sample. Damselfly and mayfly nymphs predominated in areas shaded by black willows. Overall, the sampling site on Boyd Point was not favorable for epibenthic invertebrates, due to a lack of aquatic vegetation and a barren, sandy substrate.

(e) Fish Communities.

Lake Langhofer at Boyd Point (Station 10b) was sampled with rotenone, seines and gill nets. Channel catfish and gizzard shad comprised 58.8 and 50.2 per cent of the total game and non-game fish biomass, respectively (Table D-27 appended). Common game fishes at this station included largemouth bass, white crappie, black crappie, channel catfish and six species of sunfishes. Fish species typical of large rivers or impoundments were also common: spotted gar, bigmouth buffalo (Ictiobus cyprinellus), black buffalo (I. niger), smallmouth buffalo (I. bubalus), golden topminnows, freshwater drum and yellow bass. Fish populations appeared to be well-balanced and appeared not to be adversely affected by inflowing Caney Bayou water, sand and gravel dredging operations, port activities or sewerage lines. Lake Langhofer's hydrologic connection to the Arkansas River serves to bring in sufficient nutrients and maintain a good fisheries balance.

(f) Aquatic-Oriented Reptiles and Amphibians.

The extensive backwater areas along the western shore of Lake Langhofer and the smaller backwater areas and frequently flooded woods of Boyd Point provide a variety of habitats for aquatic-oriented reptiles and amphibians. The enumeration of species would be very similar to those listed for lower Bartholomew and Caney bayous.

(g) Aquatic-Oriented Birds.

The open water and secluded backwater areas of Lake Langhofer attract a wide variety of water-oriented birds both as residents and as migrants. This variety is enhanced by the location of the lake, which lies along the important migration corridor of the Arkansas River. The variety is further enhanced by the proximity of Lake Pine Bluff and the highly productive Pine Bluff oxidation ponds on Boyd Point. This combination of the flowing water and sandbars of the Arkansas River, the quiet open water and backwater areas of Lake Langhofer, the shallow, warm, rich water of the oxidation lagoons, and the dead trees of Lake Pine Bluff and Lake Langhofer provide an incredible array of nesting, roosting, feeding and escape opportunities for a great variety of wading birds, water birds and shore birds.

At this station, migration is characterized by flocks of white pelicans, great egrets, other herons and ibis, and a variety of ducks and geese. Individuals and small groups of all species of swallows found in Arkansas pass by continually. Pectoral sandpipers (Calidris malanotos), least sandpipers (Calidris minutilla), and western sandpipers (Calidris mauri) stop to feed along the sandy beaches. Osprey perch in snags along the lake and occasionally dive at fish.

Winter is the time of waterfowl and gulls. On the lake, american coots are usually to be seen as well as small groups of ring-necked ducks (Aythya collaris), lesser scaup (Aythya affinis) and other ducks. The oxidation ponds typically harbor thousands of ducks, with ruddy ducks (Oxyura jamaicensis) being most abundant. Flocks of ring-billed gulls (Larus delawarensis) can usually be seen over the lake in winter, and herring gulls (Larus argentatus) may often be found.

Few of these species remain to nest in the spring, but the vegetated shallows along the edge of the lake do offer nesting habitat to coot, common gallinules (Gallinula chloropus), and pied-billed grebes. The timbered backwater areas contain nesting habitat for herons.

Along with some of the stream reaches, the shores of Lake Langhofer support some of the limited mature hardwood forest remaining in the study area, and this forest provides both summer and winter habitat for a variety of aquatic-oriented land birds, such as hawks, owls, sparrows, woodpeckers and warblers.

With its proximity to the Arkansas River, which is not only a major migration corridor, but is also a corridor for escape from hurricanes and for wandering by immatures and strays of many species, Lake Langhofer provides a brief stopover place for several uncommon species such as the white-faced ibis (Plegadis chihi), the oldsquaw (Clangula hyemalis), the black skimmer (Rymchops nigra) and the white-winged scoter (Melanitta deglandi).

(h) Aquatic-Oriented Mammals.

Raccoons are the predominant aquatic-oriented mammals in the vicinity of Lake Langhofer. Beavers, while not as common as in upland areas, are occasionally found in the Caney Bayou confluence area. River otter may be occasionally noted in more isolated Lake Langhofer coves and backwater areas. Nutria and mink are probably frequent visitors to the lakeshore areas.

3. Aquatic Resource Potentials.

This section addresses aquatic potentials in a step-wise process, from the type of aquatic community which was likely to have flourished prior to pioneer settlement to future conditions expected to occur without implementation of corrective or mitigative measures. Man-made waterways and lakes are deleted from the discussion because their primary function is directed largely to flood control, navigation, irrigation and managed recreation; managed Study Area lakes are assumed to be at or near their potential and man-made waterways would be unlikely to even approach potentials offered by natural bayous and streams due to inherent physical limitations.

a. The Aquatic Community Before Pioneer Settlement.

Before settlement, the lands east of the Quaternary Terrace escarpment were forested, with many areas constituting river swamps. Much of the area is no occupied by agricultural lands. Wharton (1970), quoting Eugene Odum, stated that southern river swamps may yield 20,000 Kcal/$m^2$/yr. gross primary production on average favorable sites to 40,000 Kcal/$m^2$/yr., thus ranking them with the most productive of the world's ecosystems, along with coral reefs, estuaries, and certain evergreen forests and springs. Examples of annual production estimates in such backwater areas are 397 pounds (Lambou, 1961), 400-600 pounds (Yancey, 1970), and 1,300 pounds (Wharton, 1970). Fisheries diversity was likely to be high throughout the system. Fishes, such as many of the darters were common and pelagic fishes such as gizzard shad and golden shiners were probably much less numerous in the well-shaded and heavily timbered backwaters. Diversity index values for benthic invertebrates probably exceeded 3.0 in most areas. Sludgeworms were probably present in stagnant pools, but never in population numbers like those in present urban drainages. Mayfly, damselfly and dragonfly nymphs were probably more abundant throughout the alluvial system. Turbidity levels throughout the river swamp area were probably much lower. No alligatorweed was present to alter streamflows or imbalance fish populations. Duckweeds were common in backwater ponds during dry periods of late summer and early fall and provided cover for zooplankton and food for ducks. Reptiles and amphibians were similar to those noted in present-day Study Area backwater areas except that greater areal extent of backwater areas supported concomitant numbers of herpetofauna. The American alligator, although not numerous as in coastal states, was present in sufficient numbers to alter swamp ecology with its nesting habits. Aquatic-oriented birds were more numerous and diverse, owing to the greater extent of backwater areas and unaltered habitat.

In the Quaternary Terrace, the fisheries were probably similar to those presently existing. The stream systems were shaded, with clear water and abundant snags present. Because the area was almost entirely forested, less water entered the streams; however, because of natural stream meanderings,

snags, log jams and beaver dams, water was held back in pools, providing habitat for many fishes, invertebrates and herpetofauna. Carrying capacities and species diversity were probably similar to those noted at Station 1 in 1974. Area sandy loam and silt loam soils carried into the Quaternary Terrace stream system did not enrich aquatic productivity as the clay soils of the alluvium. Amphibians, reptiles and birds were probably similar to those noted at present in unaltered bayou areas but were probably much more numerous in terrace areas presently channelized or receiving significant amounts of silt or domestic wastes. Aquatic vegetation, with the exception of alligatorweed, was probably distributed in equal abundance.

b. Aquatic Potentials.

The area with the greatest aquatic potential, the Quaternary Alluvium, could again reach this potential only through elimination of point and non-point source pollution and revegetation of the river swamp system. Two factors will determine future aquatic productivity in this area: elimination of allochthonous nutrients and sediment and maintenance and enhancement of present waterway greenbelts.

(1) Elimination of Pollutants Without Enhancement of Greenbelts.

Sedimentation eliminates sensitive aquatic species or severely restricts them. Cessation of sedimentation would probably be the greatest enhancement factor of all Study Area pollution control. Benthic diversity and fisheries productivity would increase significantly in such areas as Station 3, Bayou Imbeau and Deep Bayou. Based on Wharton's (1970) figure for fisheries productivity in stream channels, one might expect production of 75 pounds per acre. Overflow backwater areas would produce greater amounts of fish biomass, possibly as high as 400-600 pounds per acre, depending on seasonal extent and fluctuation of water levels. Without an increased greenbelt floodplain, however, these potentials will be severely limited in the alluvium. Elimination of nutrients and other pollutants in the Study Area would lower total benthic and fisheries productivity in certain areas, but would enhance species diversity. Fish such as the gizzard shad would decline in abundance, thus lowering fish biomass in many areas and increasing sport fish composition. Lower nutrient levels in bottom muds would inhibit reducing conditions and, hence, decrease the importance of sludgeworms and fingernail clams.

Pine Bluff area pollutants do not appear to be as major a limiting factor to herpetofauna and aquatic-oriented birds as does the alteration of backwater hardwood areas. Potentials for aquatic-oriented birds are additionally affected by habitat changes elsewhere.

Fisheries productivity would increase within limits in the terraces with cessation of sedimentation, in such areas as Caney Bayou above Lake Pine Bluff and Bayou Bartholomew from Princeton Pike Road to Highway 15. Because sections of both bayous are channelized, fisheries productivity in these areas will not reach that of meandering area potentials in the foreseeable future due to lower water levels, higher velocities and subsequent streambank erosion. As other forms of pollutants such as nutrients, minerals and dissolved organics do not appear to be problematic at present in the uplands, their elimination would probably not have as great an effect on

aquatic productivity as would enhancement of the narrow terrace floodplain. This would hold true not only for fishes but also for herpetofauna and aquatic-oriented birds known or theorized to be present in the upland watercourses.

(2) Enhancement of Greenbelts Without Pollution Abatement.

Areal limitations of greenbelt areas place a severe restriction upon aquatic productivity. For each additional acre of overflow backwater area, fisheries productivity could be increased from 400-600 pounds. Increased and/or enhanced backwater overflow areas vegetated with such trees as cypress, sweetgum, oaks and willows would also provide a greater variety of habitats for reptiles, amphibians and water birds. Continuing sedimentation from non-point sources would lower this value throughout the system, due to visual restrictions upon predators, smothering factors and pesticide toxicities upon prey and predator. Nutrient pollution in back-water areas would not be extremely limiting, as these areas are capable of assimilating large pollution loads and settling suspended solids. Toxic pollutants entering overflow areas from urban and agricultural areas would pose serious limitations to all aquatic flora and fauna in backwater areas, as swamp assimilation capacities are not always sufficient to handle large amounts of metals, organophosphates or chlorinated hydrocarbons.

Aquatic biota of the upland areas would benefit to a somewhat greater extent from floodplain enhancement than from pollution abatement, except in areas of serious siltation problems such as the Interceptor Canal confluence area and in channelized portions of Caney Bayou and Bayou Bartholomew. River birch, black willow and buttonbush revegetation in such areas would serve to hold waters in small pooled areas for more extensive periods than at present, thus allowing such organisms as topminnows, sunfishes, leopard frogs, dwarf American toads, newts, stinkpots, green herons and wood ducks to proliterate along the unchannelized reaches.

(3) Elimination of Pollutants With Enhancement of Greenbelts.

The combination of elimination of all pollutants, notably sediment, and enhancement and extension of presently existing bottomland hardwood swamp areas would yield the greatest aquatic potentials. Fisheries productivity in backwater areas would probably commonly exceed 400-600 pounds per acre; limited only by areal bottomland hardwood extent. Stable and diverse benthic communities would be prevalent. Elimination of allochthonous nutrient loads would enhance aquatic diversities by removal of anaerobic zones in the water column. Most aquatic-oriented organisms would benefit from this more diverse food supply as well as from an increased cover of baldcypress trees, black willows, buttonbush and typical bottomland hardwood trees such as oaks and sweetgum. Areas such as Bayou Imbeau and other wetlands would become favorable habitats for aquatic biota instead of being settling basins for sediment and biocides.

The uplands would similarly increase in biological potentials, especially in areas presently devoid of floodplain vegetation and receiving moderate sediment loads. Potentials would increase for organisms of small temporary ponds (i.e., frogs, newts, green herons, topminnows, etc.).

(4) Non-Elimination of Pollutants and Continuing Loss of Greenbelts.

Aquatic species diversities, notably in the Quaternary Alluvium, will continue to diminish with continuation of sedimentation and nutrient enrichment and loss of bottomland hardwood swamps. Eventually, aquatic productivity would be restricted to the channel itself; fish production could fall to one-tenth of the theorized 75 pounds of fish per acre. Benthic biomass would remain high due to large sludgeworm and fingernail clam populations, but diversities would fall throughout the entire system. Loss of overstory hardwoods would drastically reduce available avion habitats; herpetofauna such as painted turtles, map turtles, amphirnas and most frogs would be adversely affected by loss of shade and snag habitats.

Aquatic potentials for the uplands would approach those of present day channelized areas if pollutants continued and greenbelt areas were removed. Hardy organisms such as tubificids and mosquitofish would be dominant in such areas. Birds frequenting such areas would be mostly limited to the passerines.

c. Limiting Factors to Aquatic Potential.

All of the major limiting factors to aquatic potentials focus around the non-elimination of pollutants and degradation of overflow backwater areas. Because pollutants at present do not appear to be severly limiting to flora and fauna in most areas, the enhancement of backwater areas appears to be most critical. Continued clearing or channelization of such areas removes shade, increases flows, destabilizes streambanks, alters and removes habitat and drastically reduces swamp assimilation capacities. The inability of backwater areas to remove sediment from agricultural and constructional sources and nutrients from urban and agricultural sources, then compounds the adverse effects of habitat loss alone. Pollutional effects are then directly reflected by decreased dissolved oxygen concentration, bottom composition changes, proliferation of pollution-tolerant organisms decreased clean-water forms and subsequent losses of food to air-breathing animals dependent upon the aquatic food web.

## C. TERRESTRIAL RESOURCES.

### 1. Introduction.

In Arkansas, forest cover approximately 18,5 million acres or 55 per cent of the State (Arkansas Department of Commerce and the Arkansas Forestry Commission, 1972). There are over 500 species of woody plants in Arkansas, of which approximately 200 are trees native to the State (Moore, 1972). The diversity of Arkansas trees is primarily affected by the diversity of the topography. Figure VI-3 illustrates the four major forest types in Arkansas which are: 1) Upland Hardwood, 2) Loblolly-Shortleaf Pine-Hardwood, 3)Bottomland Hardwood and 4) Prairie or non-typed areas (Arkansas Department of Planning, 1973a).

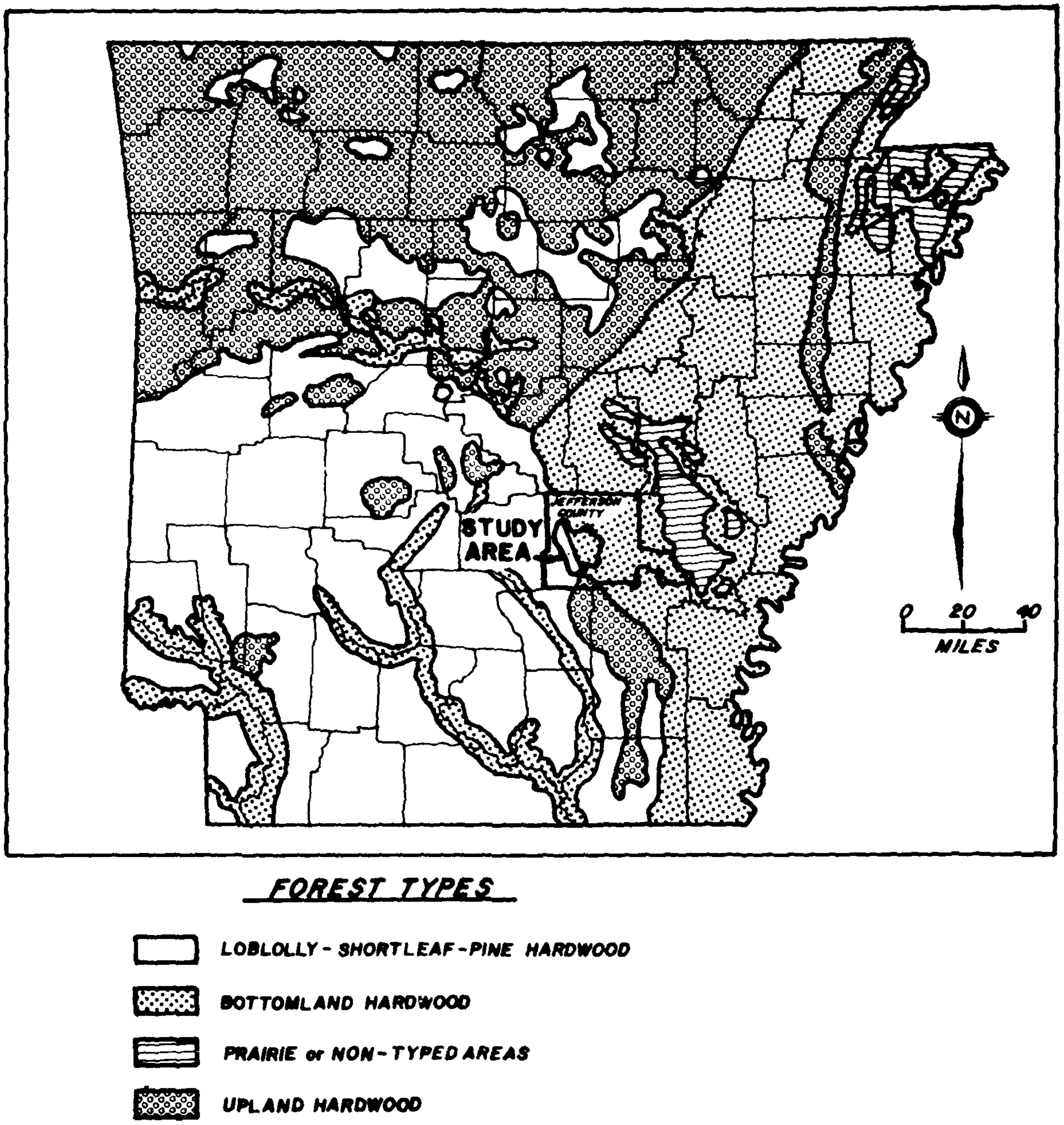



FIGURE VI-3: GENERAL FOREST TYPES OF ARKANSAS

Source: Arkansas Department of Planning, 1973a.

2. Existing Conditions.

a. Jefferson County.

Jefferson County is located in the area of transition between the Bottomland Hardwood forest and Loblolly-Shortleaf Pine-Hardwood forest (Figure VI-3). The area incorporated in the Bottomland Hardwood forest type dominated by water oak, willow oak, gum and cypress, covers about three-fourths of the eastern portion of the county and is largely cleared for agriculture. Soybeans and cotton cover nearly 200,000 acres (81,000 ha.) of the county and are the principal agricultural crops (U.S. Department of Agriculture and the University of Arkansas Agricultural Experiment Station, 1972). The remaining portion of the county is principally in the Loblolly-Shortleaf Pine-Hardwood forest type. The only exception is a small area of Upland Hardwood forest in the south-central portion of the county. See Appendix D (Table D-2) for a checklist of Jefferson County vegetation.

b. The Pine Bluff Study Area.

(1) Existing Botanical Resources.

(a) Sampling Program.

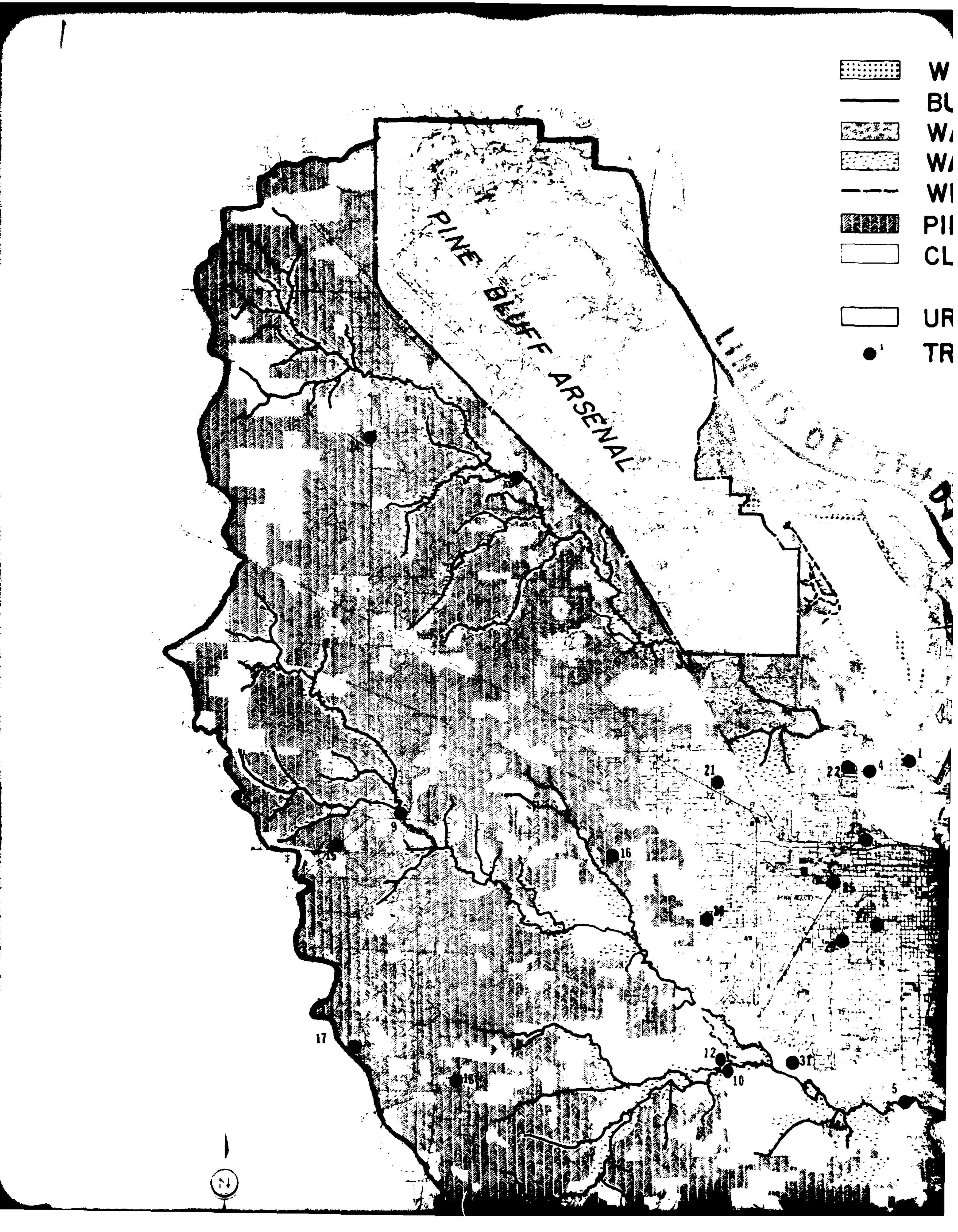
The general forest type map presented in Figure VI-3 was used to obtain a general overview of the Study Area. However, for a more detailed concept of the forest associations, the Study Area was subdivided into eight phytogeographic regions: 1) Willow-Cypress (wetlands areas), 2) River Birch-Buttonbush (river edge areas), 3) Water Locust-Water Hickory (poorly drained areas), 4) Water Oak-River Birch (moderately well drained areas), 5) White Oak-Sweetgum (natural ridge areas), 6) Pine-Post Oak (upland and terrace areas), 7) Cleared Areas, and 8) Urban Areas (Figure VI-4). The phytogeographic regions used in the report do not follow any standardized classifications, as the forest associations in the Pine Bluff Study Area are probably dissimilar to those in even nearby geographic regions. Study Area plant community names are based upon dominant overstory species in forested areas. Notes on drainage and topography of each phytogeographic unit are included in the discussion. Species composition in each phytogeographic region was determined by conducting transects; the methodology and plant lists by transect are appended (Appendix D).

(b) Results of Sampling Program.

1. Bottomland Hardwoods. The Bottomland Hardwood region comprises approximately 23,000 acres (9,312 ha.) predominantly in the eastern half of the Study Area. This region consists of the Willow-Cypress, River Birch-Buttonbush, Locust-Water Hickory and Water Oak-River Birch associations.

a. Willow-Cypress Association (Wetland Areas).

The Willow-Cypress association is located in areas inundated continuously or for most of the year and is scattered in the eastern half of the



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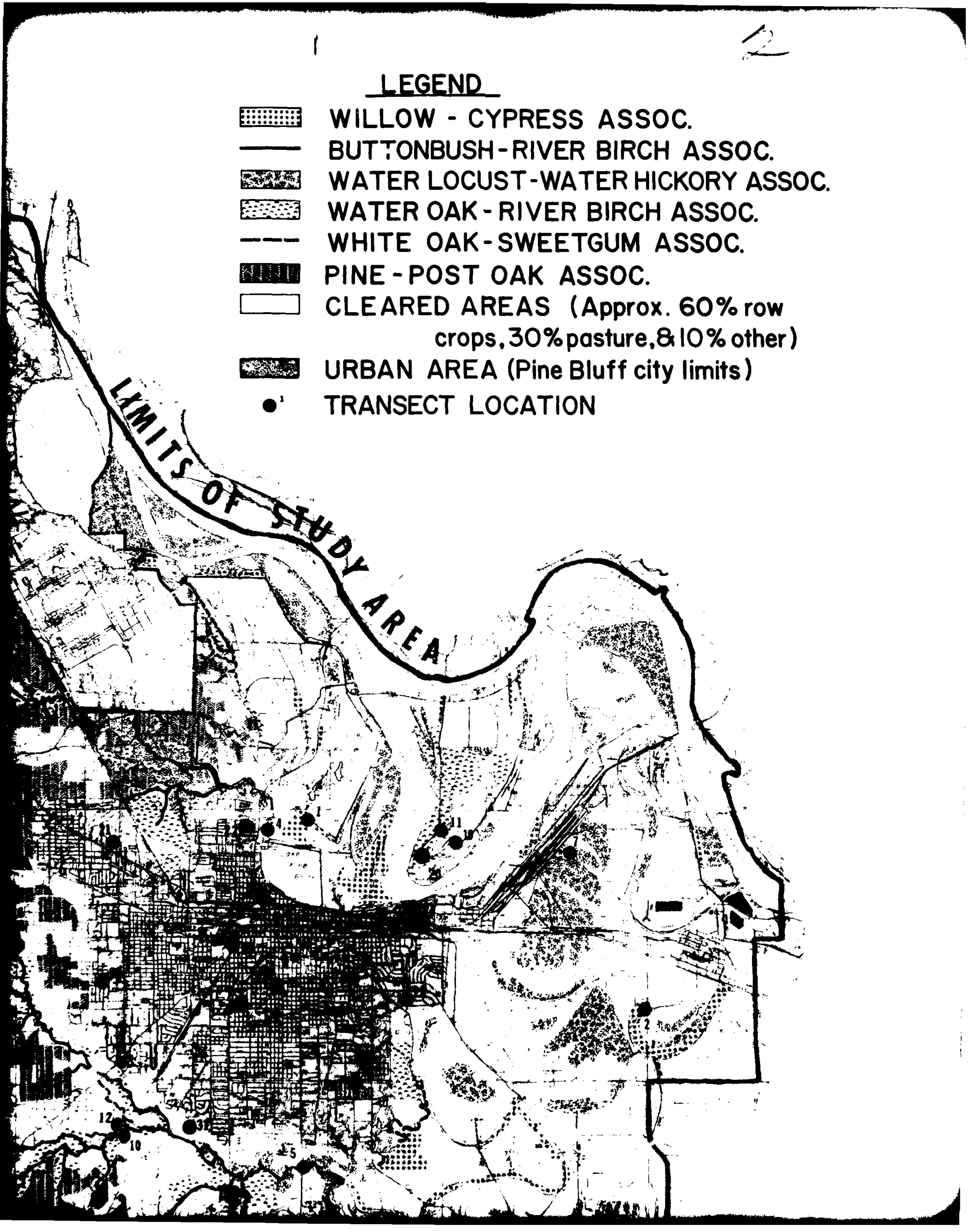
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LEGEND
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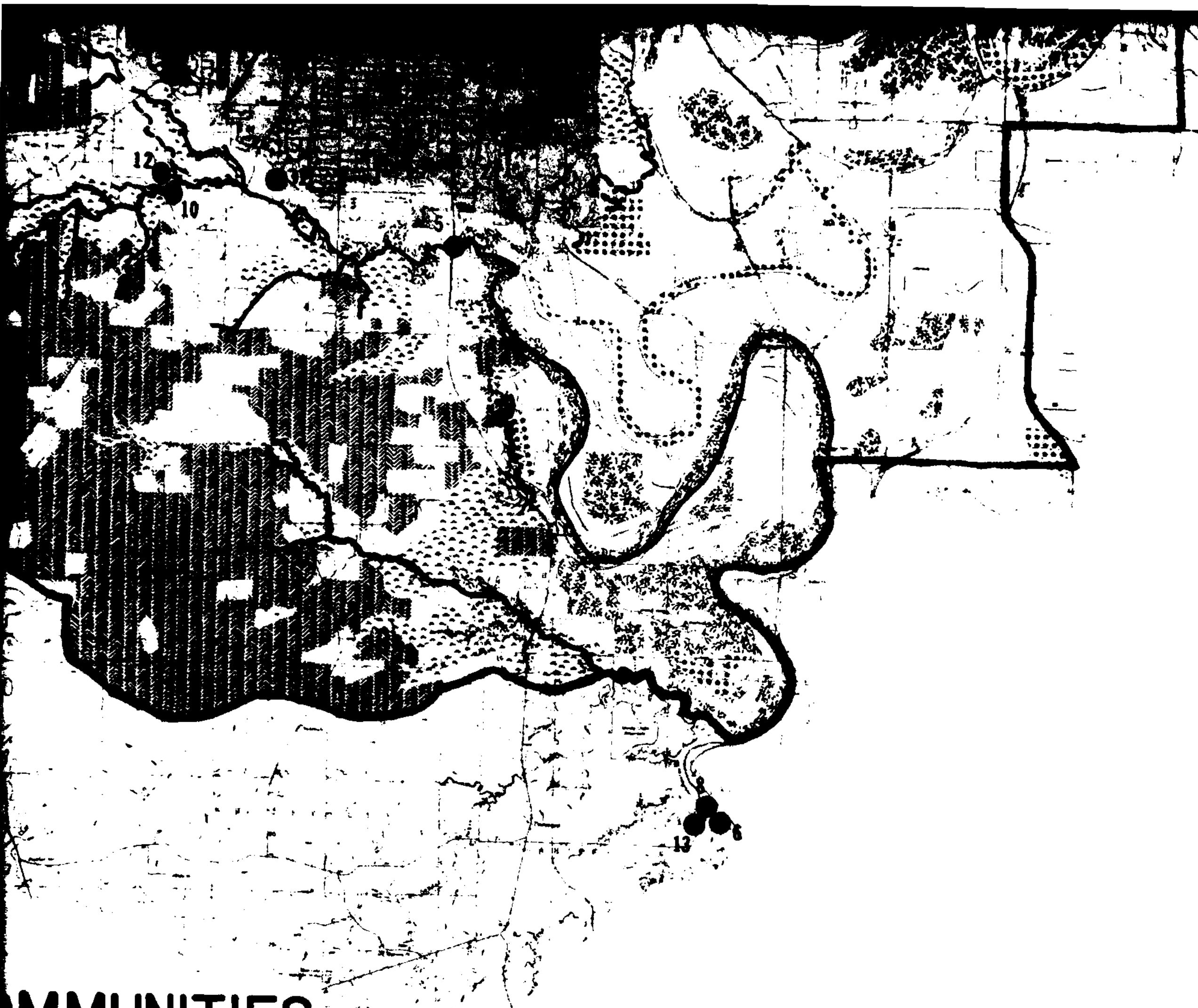
BUTTONBUSH-RIVER BIRCH ASSOC.
WATER LOCUST-WATER HICKORY ASSOC.
WATER OAK-RIVER BIRCH ASSOC.
WHITE OAK-SWEETGUM ASSOC.
PINE-POST OAK ASSOC.
CLEARED AREAS (Approx. 60% row crops, 30% pasture, & 10% other)
URBAN AREA (Pine Bluff city limits)
TRANSECT LOCATION
LIMITS OF STUDY AREA
1
4
11
2
12
10
5


# EXISTING PLANT COMMUNITIES OF THE PINE BLUFF STUDY AREA




MMUNITIES
TUDY AREA

FIG. VI - 4

2

Study Area (Figure VI-4). One of the largest continuous areas of this association occurs in Bayou Imbeau where the predominant overstory species is baldcypress (Taxodium distichum).

Species composition of the overstory is appended (Table D-31). Only six species were predominant, indicating the harsh environmental limitations in these areas. Principal overstory species were eastern cottonwood (Populus deltoides) and black willow (Salix nigra).

Limited understory composition also emphasized the harsh environmental limitations. The principal understory species was lizard's tail (Saururus cernuus). Other understory plants were switch cane (Arundinaria tecta) and small hackberry (Celtis laevigata).

Forest vegetation in wetland areas is of limited economic importance because of the high cost of harvesting. One potentially important forest tree is eastern cottonwood, which is a valuable pulpwood species and which is also cut for lumber and veneer. It attains its best commercial development on the alluvial bottomlands of the Mississippi River (U.S. Department of Agriculture, 1965 and 1973).

b. River Birch-Buttonbush Association (River Edge Areas).

The River Birch-Buttonbush association is the principal vegetation along the riverbeds. Some areas such as Ste. Marie landing and other areas along river edges tend to exhibit early successional stages. Sand bars are particularly characterized by early seral vegetative stages (such as various willows) and illustrate a very delicate community.

Species composition of the overstory is presented in Table D-32 appended. The principal overstory vegetation was river birch (Betula nigra), buttonbush (Cephalanthus occidentalis), water hickory (Carya aquatica), cedar elm (Ulmus crassifolia), baldcypress and black willow. Buttonbush was numerous in nearly all transects, but was usually too small to be classified as overstory.

Understory vegetation was most extensive in areas of heavy black willow growths. Buttonbush was the most consistent understory species in this phytogeographic region. Other common understory vegetation consisted of green-brier (Similas rotundifolia), trumpet creeper (Campsis radicans), peppervine (Ampelopsis arborea) and rose mallow (Hibiscus militaris).

c. Locust-Water Hickory Association (Poorly Drained Areas).

The Locust-Water Hickory association is located primarily in the Mississippi River Alluvial Plain. This association parallels the banks of most streams in the delta country and is also scattered within large fields of soybeans or cotton (Figure VI-4). It differs from that of wetland areas in that it is generally flooded for shorter periods.

Species composition of the overstory is presented in Table D-33 appended. Predominant species were water locust (Gleditsia aquatica), American elm (Ulmus americana), willow oak (Quercus phellos), water hickory and cedar elm.

Principal understory vegetation was Japanese honeysuckle (Lonicera japonica), greenbrier, yellow jessamine (Gelsemium sempervirens) and summer grape (Vitis aestivalis).

d. Water Oak-River Birch Association (Moderately Well-Drained Areas).

The Water Oak-River Birch association is confined to the better drained bottomland areas along streams and comprises the principal forest community on Boyd Point (Figure VI-4). Topography and soil characteristics generally determine the boundaries of this association. Soil characteristics on Boyd Point exhibit considerable variation in drainage features and, consequently, result in greater species diversity.

Overstory species composition for this association is presented in Table D-34 appended. Principal overstory species were water oak (Quercus nigra), blue beech (Carpinus caroliniana), sweet pecan (Carya illinoensis) and river birch.

Understory was generally dense and varied. Some of the most frequently observed understory species were greenbrier, French mulberry (Callicarpa americana), poison ivy (Rhus radicans), summer grape and Japanese honeysuckle.

2. Pine-Upland Hardwoods.

The Pine-Upland Hardwoods region comprises approximately 52,000 acres (22,834 ha.) predominantly in the western half of the Study Area. This region consists of the White Oak-Sweetgum and the Pine-Post Oak associations.

a. White Oak-Sweetgum Association (Natural Ridge Areas).

The White Oak-Sweetgum association occurs as narrow strips along natural ridges and levees (Figure VI-4). Although an abrupt increase in elevation was one of the principal criteria for determining the location of these areas, it was not the only criteria. Rather than designate every sharp change in topographic relief, the areas chosen to represent this association are indicative of transitional areas where species of both lowland and upland intermix (see also Table D-35 appended).

Understory species were abundant and diverse, the most common species being redbud (Cercis canadensis), greenbrier (Similax glauca), red maple (Acer rubrum), blackgum (Nyssa sylvatica) and peppervine. A dense grass cover of Panicum sp. and Paspalum sp. was noted in open areas.

b. Pine-Post Oak Association (Upland and Terrace Areas).

The Pine-Post Oak association is the largest forest association in the Study Area. It encompasses hill lands west of Arkansas Highway 15 (Figure VI-3).

The principal overstory species in this association were loblolly pine (Pinus taeda), post oak (Quercus stellata), sweetgum and blackgum, although many bottomland hardwoods were represented (Table D-36 appended).

Understory was varied and sporatic, often sparse to moderate in poorly lighted areas and dense in open areas. Small blackgum and sweetgum trees were very numerous. Other common understory species included huckleberry (Vaccinium sp.), dogwood (Cornus sp.) and Japanese honeysuckle, and in open areas, grasses and sedges.

3. Disturbed Areas.

Extensively modified areas such as urban and agricultural lands are classified as disturbed areas. As such, the native vegetation has been removed or disturbed and the climax state disrupted. The disturbed areas comprised approximately 48,000 acres (19,433 ha.) scattered throughout the Study Area with major concentrations occurring east of Arkansas Highway 15 and within the city limits of Pine Bluff.

a. Cleared Areas. About 60 per cent of this area consists of land cleared for row crops, primarily cotton and soybeans. This large portion of Cleared Area was concentrated in the flat Mississippi Alluvial Plain east of Arkansas Highway 15 (Figure VI-4). About 30 per cent of Cleared Area is in pasture. Pasture areas are scattered throughout the rolling upland areas west of Arkansas Highway 15. The remaining 10 per cent of cleared areas consists of small residential areas along highways, clear-cut forest tracts and any other areas not cleared for row crops or pasture. No transects were conducted in row crop areas.

Principal overstory vegetation was American plum (Prunus americana), American sycamore (Platanus occidentalis), black willow and honey locust (Gleditsia triacanthos). Black willow was abundant in a small low area. American plum occurred in dense thickets, so it could not be quantified. The remaining trees were generally scattered (see also Table D-37 appended).

The majority of the species in this area consisted of understory plants such as horse mint (Monarda sp.), lead plant (Amorpha canescens), golden aster (Heterotheca sp.), evening primrose (Oenothera sp.), tickseed (Coreopsis tinctoria), grasses and sedges.

b. Urban Area.

The Urban Area is located within the Pine Bluff city limits (Figure VI-4). Since a wide diversity of plants was expected in this area, extensive sampling was conducted.

The principal overstory species were sweetgum, American elm, water oak, sweet pecan and black willow (Table D-38 appended).

Understory plants consisted of various grasses and sedges. Principal grasses were represented by species of Cynodon, Panicum and Paspalum; sedges, primarily by species of Carex and Cyperus.

(2) Existing Zoological Resources.

Because of the dependence of animals upon the composition, distribution and abundance of plants, the zoological resources are described according to the phytogeographic areas previously described in Figure VI-4. Checklists of animals occurring in the proximity of the Study Area are appended (Tables D-28, D-29, and D-30).

A general zoological comparison of forest associations is often based on carrying capacity which is defined by Storer et al. (1957) as the maximum population number that can be attained under existing conditions. This maximum number, however, is often tempered by many environmental factors such as droughts and flooding. Thus, there may often be a significant disparity between potential capacity and existing population size based on systematic sampling programs.

The lack of detailed wildlife sampling programs in the Pine Bluff area has created some difficulty in evaluating zoological resources. The most detailed information has been on birds, which was compiled by the Jefferson Audubon Society. Another source of information for zoological resources was a study on the Pine Bluff Arsenal (Pinkham et al., 1972). Because it was beyond the scope of work to conduct a detailed wildlife sampling program, these two data sources were utilized in conjunction with Conant (1958), Lowery (1974) and the Arkansas Game and Fish Commission (pers. comm.).

A general description of the zoological resources occurring in the major phytogeographic associations (bottomland hardwoods, pine-upland hardwoods, and disturbed areas) follows.

(a) Bottomland Hardwoods.

The Bottomland hardwoods of the lower Mississippi River Valley is one of the most productive wildlife habitats on the continent and it supports a wide diversity of animal life (Yancey, 1970). The bottomland hardwoods in the Study Area encompass about 23,000 acres (9,312 ha.) or 31 per cent of the forested areas and are composed of wetland areas, poorly-drained and moderately well-drained bottomland hardwood areas, and river edge areas.

1. Mammals.

The principal mammals in the bottomland hardwoods are deer, squirrel, rabbit and raccoon. These animals, particularly deer and squirrel, depend heavily on the mast producing capability of bottomland hardwoods. A brief description of some of the principal forest mammals and their habitats follows.

a. White-Tailed Deer.

The white-tailed deer (*Odocoileus virginianus*) is both abundant and widespread in Arkansas. In the southern part of the State, whitetail deer breed from late September to early March. Because its former chief predators, panthers and wolves, are rare and endangered throughout all of

the State, the deer populations are presently controlled only by man and domestic dogs. Bottomland hardwood swamps offer white-tailed deer extensive cover.

Bottomland soils are fertile, well-watered and produce high quality browse. In Louisiana, Collins (1961) reported that bottomland oaks produce more acorns per tree than upland oaks and that most production was consistently high from year to year. The benefit of high quality browse in open areas and consistently high mast production stimulate excellent carrying capacities of deer. In bottomland areas, deer carrying capacity ranges from one deer per six acres (2.4 ha.) in bottomland forests intermixed with soybean production (Noble, pers. comm.) to one deer per 40 acres or 16.2 ha. (St. Amant, 1959). Yancey (1970) states that there is a general carrying capacity of one deer per 20 acres (8.1 ha.) in bottomland hardwoods.

Although properly managed bottomland hardwoods have tremendous potential for deer production, much of the bottomland hardwoods in the Study Area occur in small, isolated patches surrounded by extensive cotton fields. These patches have limited deer capacity because they provide little escape cover.

b. Squirrels.

Squirrels are a popular game animal in Arkansas. Squirrels, particularly the grey squirrels (*Sciurus carolinensis*) have been noticed to have a special "preference" for bottomland hardwoods (Madson, 1964; Stransky and Halls, 1968). The fox squirrel (*Sciurus niger*) also occasionally occurs in the bottomland forest although its preferred habitat is upland hardwood and hardwood-pine forests.

Both fox and grey squirrels have two major breeding periods in Arkansas, one in spring and one in summer. Both squirrels consume practically every kind of vegetable food available. Primary predators, excluding man, include foxes, bobcats, weasels, owls and red-shouldered hawks. Carrying capacity estimates for middle-aged to old stands of bottomland forest range from 0.7 squirrels per acre (Lowery, 1974) to 1.3 animals per acre (Yancey, 1970).

c. Rabbits.

Rabbits are also popular game animals in Arkansas and occur over a wide variety of habitats. The cottontail rabbit (*Sylvilagus floridanus alacer*) occurs in most areas of Arkansas and the swamp rabbit (*Sylvilagus aquaticus aquaticus*), although widely dispersed, is most prevalent in wet areas and along river edges. Cottontails eat a variety of grasses, both natural and cultivated while swamp rabbits prefer grasses, sedges and cane. Both breed prolifically and are hunted by great horned owls, foxes, coyotes, bobcats, minks, weasels and striped skunks, as well as man.

Bottomland hardwood carrying capacity for swamp rabbits is about one animal per two acres (0.8 ha.; Yancey, 1970) and for both swamp and cottontail rabbits, about 1.5 to 2 rabbits per acre (0.4 ha.; Noble, pers. comm.).

d. Other Mammals.

Other mammals frequently encountered in the bottomland hardwoods of the Study Area include the raccoon (Procyon lotor), the beaver (Castor canadensis), the mink (Mustela vison), the otter (Lutra canadensis) and the opposum (Didelphis virginiana). All of the wetlands forming a significant portion of the bottomland hardwood forests provide valuable habitats for these animals. In addition, the river edge areas also provide excellent habitat for beaver.

The raccoon is especially abundant in the bottomland hardwoods of southeast Arkansas and is the principal furbearer in the State. It provides excellent sport to the hunter, in addition to providing economic revenue from the sale of its meat and pelt. Bottomland hardwood forests have a carrying capacity of about one raccoon per 10 acres (4.0 ha.). Mink and opossum are also sought for their pelts, and opossum is occassionally consumed by locals. Carrying capacities for mink and opossum are about one animal per 30 acres (12.1 ha.) and one animal per 10 acres (4.0 ha.), respectively. Little is known about the carrying capacity of beaver or otter.

2. Avifauna.

Bottomland hardwoods provide habitat for a wide diversity of birds. Principal game species include turkey, wood ducks and migrant waterfowl. Many non-game birds also proliferate in this forest type.

a. Turkey.

The frequency of turkey (Meleagris gallopavo)in the bottomland hardwoods can be illustrated by evaluating hunter harvest values. Stransky and Halls (1968) determined that ten Arkansas counties (excluding Jefferson County) accounted for 67 per cent of the turkey harvest for the State. These counties consisted mainly of bottomland forests. Bick (1947) noted 78 per cent of the turkey population in Louisiana inhabitated similar areas. Carrying capacity for wild turkey is estimated to be one turkey per 75 acres (30.4 ha.; Yancey, 1970).

The existing turkey population in the bottomland hardwoods of the Study Area is probably below its potential carrying capacity; only two turkeys were harvested in Jefferson County during the 1970 hunting season (Kaffka, 1974). One of the primary causes of the low turkey density in the Pine Bluff area is the lack of continuity of the bottomland forests. Much of this forest type is scattered in agricultural fields reducing the wildlife of this forest type.

b. Wood Ducks and Migrant Waterfowl.

Wood ducks (Aix sponsa) and migrant waterfowl provide considerable recreational and economic opportunity for hunters, birdwatchers and other outdoorsmen. Overflow areas in bottomland forests furnish excellent habitat for these birds. The forested areas along Bayou Bartholomew are well suited for wood duck production. Migrant waterfowl are more abundant north of the Arkansas River in flooded bottomland areas bordering rice fields than in the Study Area.

Carrying capacity of typical bottomland hardwoods for wood ducks and migrant waterfowl is one wood duck per 100 acres (40.5 ha.) and one migrant waterfowl per 10 acres (4.0 ha.; Yancey, 1970). Existing conditions in the Study Area are likely below the above figures.

c. Other Avifauna.

Bottomland hardwoods also provide habitat for a wide variety of non-game birds. The wetlands, waters and woods of the Study Area bottomlands provide habitat for grebes, herons, ducks, geese, hawks, owls, shorebirds, woodpeckers and many perching birds. Most of these birds have declined as the woods have been drained and cleared and they therefore function as valuable indicators of land use changes. Some, such as the southern bald eagle (Haliaeetus leucocephalus leucocephalus), which formerly nested in the county, and the peregrine falcon (Falco peregrinus), which wanders through the county, are presently listed on the United States Fish and Wildlife Service's Endangered Species List. Others, such as most of the herons, are threatened as breeding species in Arkansas, even though their national populations are fairly stable. Still others, such as many of the warblers, are declining locally in the bottomlands of the Study Area, but are not yet threatened on a state-wide basis. Endangered and threatened species are treated in more detail in section VI-D.

Typical bottomland species whose abundance is declining in the Study Area but which are not yet threatened include the green heron, cooper's hawk (Accipiter cooperii), american woodcock (Philohela minor), spotted sandpiper (Actitis macularia), solitary sandpiper (Tringa solitaria), yellow-billed cuckoo, great horned owl (Bubo virginianus), chuck will's widow (Caprimumgus carolinensis), belted kingfisher and red-headed woodpecker. Declining bottomland passerines include the eastern phoebe, brown creeper (Certhia familiaris), winter wren (Troglodytes troglodytes), veery (Catharus fuscescens), prothonotary warbler, northern parula warbler, cerulean warbler (Dendroica cerulea), Louisiana waterthrush, Lincoln's sparrow (Melospiza lincolnii) and swamp sparrow (M. georgiana).

By contrast, some typical grassland species have increased their numbers during clearing and draining of the hardwoods. These include the red-tailed hawk, mourning dove, horned lark (Eremophila alpestris), scissor-tailed flycatcher (Muscivora forficata), Mississippi kite, vesper sparrow (Pooecetes gramineus) and Lapland longspur (Calcarius lapponicus). Typical bottomland species which have maintained or increased their population levels are virtually limited to red-winged blackbird (Agelaius phoeniceus) and common grackle (Quiscalus quiscala).

3. Herpetofauna.

Bottomland hardwoods of the Pine Bluff Study Area have a wide variety of reptiles and amphibians. Some common reptiles include the western mud snake (Farancia abacura reinwardti), western cottonmouth (Agkistrodon piscivorus leucostoma) and the five-lined skink (Eumeces fasciatus). Other common bottomland hardwood reptiles and amphibians are discussed in Section VI.B.2.

4. Invertebrates.

Bottomland forests contain habitats for both terrestrial and aquatic invertebrates. These organisms are important components in the food web. They are consumed by many of the important commercial and sport fishes and many kinds of birds, small mammals, reptiles and amphibians. This forest type contains numerous millipedes and centipedes, particularly in the moist forest liter, as well as numerous ants, bees, wasps, beetles, snails, gnats, ticks, earthworms, spiders and mosquitoes. Bottomland areas such as small pools and streams contain numerous aquatic invertebrates such as damselfly nymphs, dragonfly nymphs, dipteran larvae, aquatic beetles, amphipods, leeches, crawfish, grass shrimp, and a wide variety of microorganisms such as rotifers and copepods.

(b) Pine-Upland Hardwoods.

The Pine-Upland Hardwood forest in the Study Area covers approximately 52,000 acres (22,834 ha.) or 69 per cent of the forested Study Area. Next to the Bottomland Hardwood forest, the Pine-Upland Hardwood forest generally provides the best overall wildlife habitat in the southeast United States.

1. Mammals.

a. White-tailed Deer.

Deer are influenced by the quality and availability of browse and mast. Segelquist and Pennington (1968) found no significant browse yield differences between bottomland hardwood areas and pine-upland hardwood areas in the Oklahoma Ouachitas. Although browse conditions may be similar in those two forest types, production of mast differs slightly. Lay (1965) showed that the Pine-Upland Hardwood forest of the southeast United States is second only to the Bottomland Hardwood forest in the production of mast. Since mast production in the Pine-Upland Hardwood forest is less abundant and is available for shorter periods of time than in bottomland hardwood areas (Stransky, 1969), deer carrying capacities are smaller in this forest type than in bottomland hardwood areas. Some estimates of Pine-Upland Hardwood carrying capacities for deer caries from one deer per 26 acres (10.6 ha.; Moore and Strode, 1966) to one deer per 50 acres (20.2 ha.; Moore, 1967).

Although deer carrying capacity in a typical Pine-Upland Hardwood forest is less than in the typical Bottomland Hardwood forest, existing deer populations in the Study Area may exhibit an inverse relationship. This supposition is based on current land use patterns in the Study Area. Portions of the Pine-Upland Hardwood forest are managed for pulpwood and sawtimber production, resulting in occasional clear-cut openings where browse plants flourish and provide valuable food for deer. Another valuable asset of the Pine-Upland Hardwood forest is the continuity of this forest type.

b. Squirrels.

Pine-Upland Hardwood forests contain both grey and fox squirrels. Fox squirrels, unlike grey squirrels, prefer the Pine-Upland Hardwood forest (Madson, 1964). Carrying capacity for these squirrels in Pine-Upland Hardwood forests is one animal per 2 acres (0.8 ha.).

One of the principal squirrel density limitations of this forest type is the current land use practice of clearcutting. This practice eliminates food and den sites.

c. Rabbits.

Cottontail rabbits occur in the Pine-Upland Hardwood forest. Clearcutting is beneficial to rabbit populations by providing food and cover. Carrying capacity is about 1.5 rabbits per acre (0.4 ha.).

d. Other Mammals.

As in bottomland forests, Pine-Upland Hardwood forests provide suitable habitat for raccoon, opossum, mink and beaver. In addition, red and grey foxes (Vulpes fulva and Urocyon cinereoargenteus), flying squirrel (Glaucomys volans), striped skunk (Mephitis mephitis) and other small rodents are common in these forests.

2. Avifauna.

a. Turkey.

The typical Pine-Upland Hardwood forest is well suited for turkey habitation, although generally less suited than typical bottomland areas. Turkey carrying capacity in Pine-Upland hardwoods is about one turkey per 100 acres (40.5 ha.). Hollis (1950) established a set of hypothetical specifications for ideal turkey habit. He concluded that a forest tract should be large, a minimum of 10,000 acres (4,048 ha.), and should consist of at least 50 per cent hardwoods, of which half should be oaks. The Pine-Upland Hardwood forest in the Study Area tends to generally satisfy these two turkey requirements; turkey populations are, however, severly limited in these areas due to high accessibility to humans and clearcutting of large areas.

b. Quail.

Quail (Colinus virginianus) have been shown to prefer pine stands over hardwoods (Stransky and Halls, 1968). Stands of predominantly pine are sparse in the Study Area, but the mixture of pine and hardwoods provides very good habitat for these birds. Seeds from pine, sweetgum, maple, dogwood and oaks are all consumed by the quail (Bateman, 1959). Clearcutting a common silvicultural practice in the Study Area, is beneficial to quail, because it stimulates growth of valuable foods such as legumes and grasses. Seeds comprise 85 per cent of a quail's diet and legumes and grasses are the major sources of these seeds (Byrd and Holbrook, 1974).

c. Wood Ducks and Migrant Waterfowl.

The Pine-Upland Hardwood forest is generally unsuited for wood ducks and migrant waterfowl and is seldom visited by them, primarily because few ponded or overflow areas exist in this community.

d. Other Avifauna.

The abundance of food and cover in the Pine-Upland Hardwood forest provides excellent habitat for numerous nongame species, including the broad-winged hawk (Butéo playpterus), pine siskin (Spinus pinus), red crossbill (Loxia curvirostra), and chipping sparrow (Spizella passerina).

Clearcutting is the major current land use practice affecting birds of this forest type in the study area. By removing standing timber, many species of birds such as the red-headed and red-cockaded woodpeckers (Melanerpes erythrocephalus and Dendrocopus borealis, respectively), the white-breasted nuthatch (Sitta carolinensis), brown-headed nuthatch (Sitta pusilla), and pine warbler (Dendroica pinus) are decreasing in abundance. This same land use practice, in conjunction with clearing for pasture, is having the opposite effect on other birds such as the red-tailed hawk (Buteo jamaicensis), prairie warbler (Derdroica discolor), eastern meadowlark (Sturnella magna) and Bachman's sparrow (Aimophila aestivalis). Some western birds, such as the roadrunner (Geococcyx californianus) and the scissor-tailed flycatcher (Muscivora forficata) are also sighted more frequently than in the past, but the reason for this occurrence is uncertain.

3. Herpetofauna.

The Pine-Upland Hardwood forest contains many species of reptiles but few amphibian species. Common reptiles in this forest type include the black racer (Colubar constrictor priapus), southern ringnecked snake (Diadophis punctatus stictogenys), red-bellied snake (Storeria occipitomaculata occipitomaculata), three-toed box turtle (Terrapene carolina triunguis), ground skink (Lygosoma laterale), and the broad-headed skink (Eumeces laticeps). A few common amphibians such as the east Texas toad (Bufo woodhousei velatus) and the grey treefrog (Hyla versicolor) occur in Pine-Upland Hardwood forests in the Study Area.

4. Invertebrates.

The invertebrate community in the Pine-Upland Hardwood forest is composed primarily of various species of beetles, ants, snails, bees, wasps, gnats, spiders and flies. Some common insect pests in Pine-Upland Hardwood forests include; southern pine beetles, pine engraver beetles, turpentine beetles, Pales weevils, red-headed pine sawflied, pine webworms, Nantucket pine tip moths, hickory bark beetles, two-lined chestnut borers, oak leaf miners and fall webworms.

c. Disturbed Areas.

Cleared and urban areas alone provide little habitat for most wildlife. However, when these areas occur in conjunction with forested areas, they are often important. Deer, turkey and quail all benefit from this edge effect but seldom do these wildlife species occur in open spaces. To avoid overlapping previous discussions, cleared areas will be considered only as the term indicates (excluding overstory species) and urban areas will be evaluated only within the Pine Bluff city limits.

1. Mammals.

a. Deer.

Deer very seldom occur in urban areas. Overgrown clear cut areas are browsed by deer and areas cultivated in soybeans and pastures are heavily utilized by these big game animals.

b. Squirrels.

Fox and grey squirrels are abundant in urban areas due to the occurrence of many hardwood timber species. These trees, absent in cleared areas, provide food and den sites. Another food source available year-round in urban areas is backyard bird feeders.

c. Rabbits.

Cottontail rabbits occur in both urban and cleared areas. In urban areas, these mammals are concentrated in residential communities where available escape cover such as overgrown woodlots and small wooded areas occur.

d. Other Mammals.

Rodents probably represent the greatest single group of mammals occurring in cleared and urban areas. These mammals, excluding squirrels, proliferate in both of these environments and can, in urban areas, occassionally create health hazards. Many species of mice, rats and gophers are common. Some other common mammals in urban and/or cleared areas include bats, opossums and moles.

2. Avifauna.

a. Turkey.

Turkeys do not occur in urban areas. However, overgrown clearcut areas, when bordered by forests, are utilized by turkeys for food and nest sites.

b. Quail.

Urban areas are not commonly utilized by quail; however small wooded areas within the southwestern Pine Bluff city limits do contain sparse quail populations. Cutover areas near forest cover are utilized by quail for food and nest sites, if grasses and legumes occur. Agricultural areas, particularly in the eastern portion of the Study Area, contain little quail food plants and, consequently, contain few quail.

c. Wood Ducks and Migrant Waterfowl.

Wood ducks and migrant waterfowl occasionally occur in flooded soybean and rice fields in the Study Area. Within the Pine Bluff city limits, these birds, particularly wood ducks, occassionally occur along the periphery of Lake Pine Bluff and within the southern city limits near Bayou Bartholomew.

d. Other Avifauna.

The habitat of urban areas is favorable for some birds, but most species decline as natural habitat is urbanized. Species which thrive in urban areas include rock dove (Columbia livia), house sparrow (Passer domesticus), blue jay (Cyanocitta cristata), chimney swift (Chaetura pelagica) and common nighthawk (Chordeiles minor). If nest boxes are provided, purple martins (Hirundo rustica) do well. Virtually all others disappear. Many are extirpated. Certain species will reestablish as urban trees and shrubbry mature. This process is noticeable in about 10 years after development and reaches maximum attraction in about 25 years.

the occurrence of Swainson's hawk (Buteo swainsoni). Agricultural areas east of Pine Bluff have caused an increase in barn swallows (Hirudo rustica) and starlings (Sternus vulgaris) but, through the elimination of sloughs and bottomland forests, have caused a decline in the pied-billed grebe (Podilymbus podiceps), various species of herons and owls, and many passerines. Agriculture has prompted an abundance of starlings which feed in fields and roost in Urban Areas. One such roost occurs along Olive Street in southern Pine Bluff and is a potential health hazard.

3. Herpetofauna.

Common reptiles and amphibians occurring in disturbed areas include the southern copperhead, the smooth earth snake, the prairie kingsnake, the three-toed box turtle, the six-lined racerunner (Cnemidophorus sexlineatus), the slender grass lizard (Ophisaurus attenuatus), the green treefrog and the southern leopard frog.

4. Invertebrates.

Cleared and urban areas contain habitats suitable for aquatic and terrestrial invertebrates. Many species of flies, grasshoppers, gnats, bees, wasps, beetles, ants, mosquitoes and roaches occur in the terrestrial community. Small canals and ditches, particularly in the urban area, provide habitat for mosquito larvae, mayfly, dragonfly and damselfly nymphs, various water beetles and several kinds of small crustaceans such as grass shrimp, crayfish and amphipods. Certain species of mosquitoes may serve as a vector for encephalitis.

3. Evaluation of Terrestrial Potentials and Limiting Factors.

a. Terrestrial Resource Potentials.

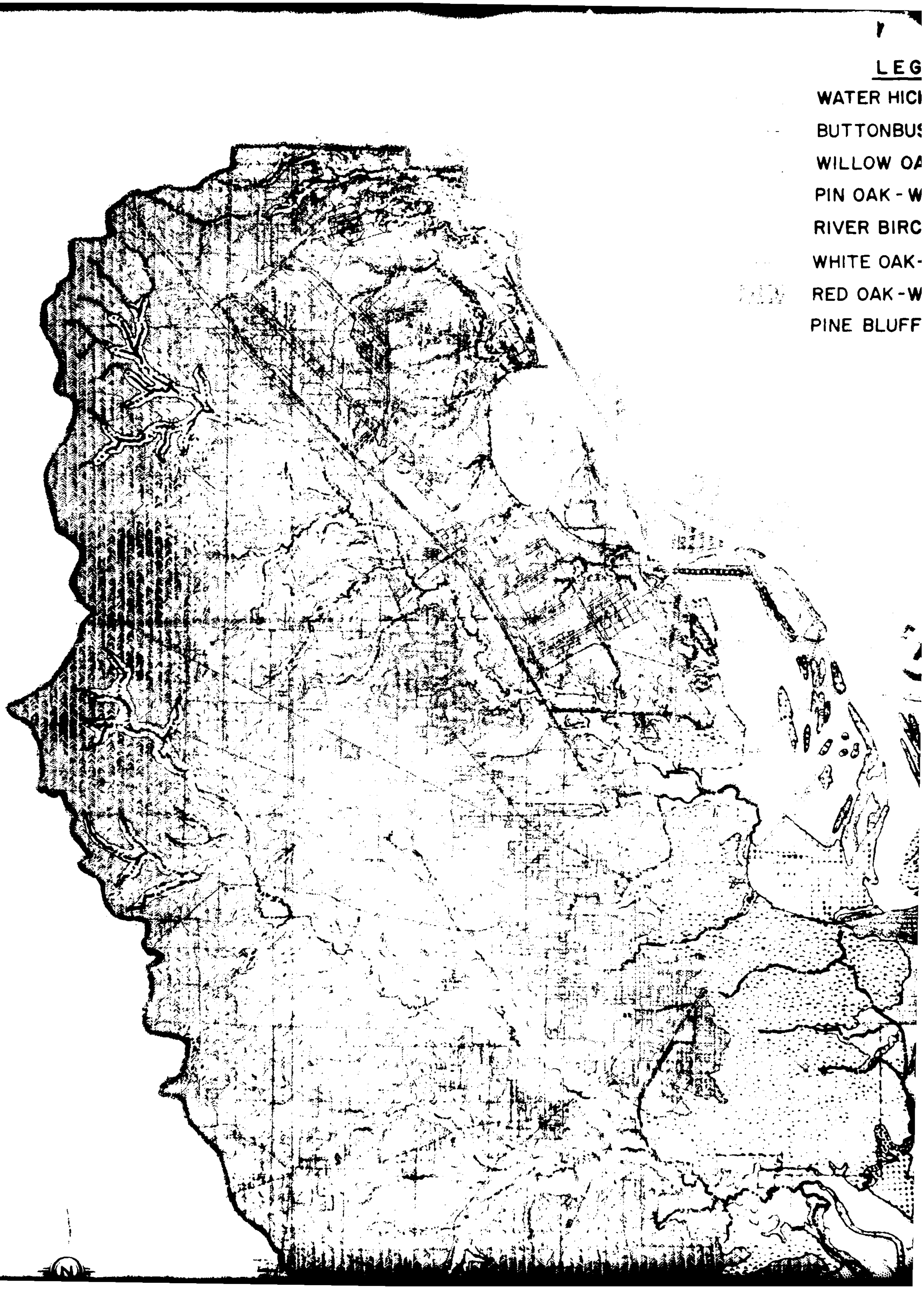
Potential terrestrial resouces are based on a hypothetical vegetational climax for the entire Study Area with corresponding changes in animal communities.

Anticipated forest climax associations of the Study Area are presented in Figure VI-5. These forest associations are based on existing forest conditions, drainage, topography and vegetation descriptions discussed by the Arkansas Department of Planning (1974).

(1) Potential Botanical Resources.

(a) Bottomland Hardwoods.

Bottomland Hardwood forests would occur primarily in the flat, eastern portion of the Study Area. A small segment of this forest type would be distributed along the river bottoms in the hill lands. Wharton (1970) estimated that mature bottomland hardwoods could be cropped ever 33.3 years at a present value (1969 dollars) of $158 per acre stumpage and $506 per acre as lumber.

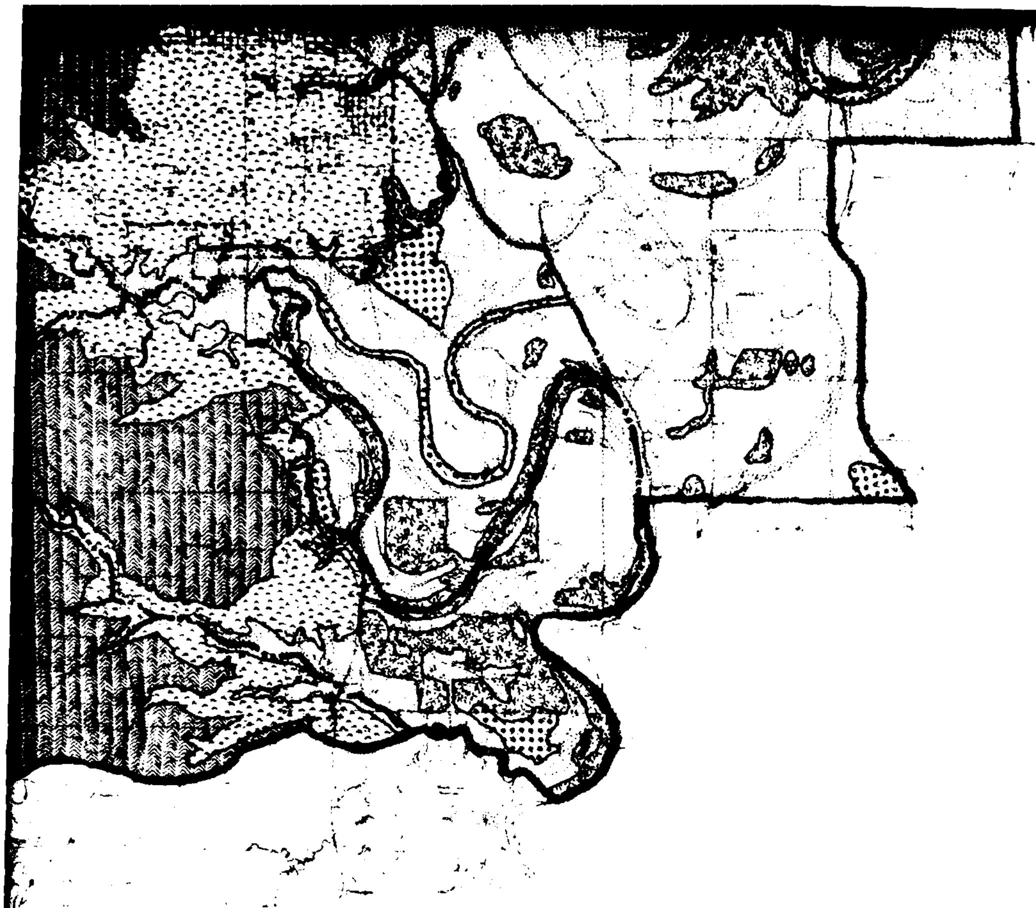

LEG
WATER HICI
BUTTONBUS
WILLOW OA
PIN OAK - W
RIVER BIRC
WHITE OAK-
RED OAK - W
PINE BLUFF
N

2

## LEGEND

- WATER HICKORY - OVERCUP OAK ASSOC.
- BUTTONBUSH - RIVER BIRCH ASSOC.
- WILLOW OAK - NUTTAL OAK - SWEETGUM ASSOC.
- PIN OAK - WATER OAK ASSOC.
- RIVER BIRCH - AMERICAN ELM ASSOC.
- WHITE OAK - SWEETGUM ASSOC.
- RED OAK - WHITE OAK - HICKORY ASSOC.
- PINE BLUFF URBAN & ARSENAL BOUNDARIES

# POTENTIAL VEGETATION OF THE PINE BLUFF STUDY AREA



TATION
TUDY AREA

FIG. VI - 5

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1. Water Hickory-Overcup Oak Association.

This forest association would occur in areas subjected to frequent and prolonged flooding. The most common associates would be hackberry, baldcypress, black willow and water locust.

2. Buttonbush-River Birch Association.

Areas immediately adjacent to streams would be forested with this vegetative association. Common associated species would be water hickory, water elm and baldcypress.

3. Willow Oak-Nuttall Oak-Sweetgum Association.

This forest association would occur on poorly-drained sites. In addition to the major species, this association would contain water locust, water hickory and American elm.

4. Pin Oak-Water Oak Association.

This association would be prevalent in flat, delta areas presently cleared for croplands. Drainage is slightly better on these sites than on the poorly-drained areas occupied by the Willow Oak-Nuttall Oak-Sweetgum association. The most common associates would be persimmon, hawthorns and hackberry.

5. River Birch-American Elm Association.

This forest association would occur on moderately well-drained soils bordering major stream bottoms. Other species probably would include blue beech, sweet pecan, water oak, and hackberry.

(b) Upland Hardwoods.

Upland hardwoods are dominant in the western portion of the Study Area.

1. White Oak-Sweetgum Association.

This forest association would be prevalent along natural ridges forming transition zones between bottomland and upland hardwoods. Associated species would include southern red oak and water oak.

2. Red Oak-White Oak-Hickory Association.

This association would occur in the upland and terrace areas. Principal associated species would include blackgum, sweetgum and southern red oak.

(c) Disturbed Areas.

Disturbed areas would be caused by natural phenomena such as wildfires, wind, ice storms, tornadoes, and insect and disease attacks.

The temporary openings created by these natural occurrences would generally be small and scattered throughout the Study Area. Vegetation in these openings would consist of various species of grasses, composites, legumes and sedges.

(2) Potential Zoological Resources.

Potential zoological resources are also based on a hypothetical climax situation. The absence of man and the anticipated abundance of mast-producing hardwood forest species should increase wildlife potential in the Study Area. Potential carrying capacities of the two major anticipated forest types are presented in Table VI-4. Most forest animals, particularly squirrels and turkeys would increase due to the additional forested areas. Small natural forest clearings would increase deer, quail and turkey populations.

(a) Mammals.

Squirrels and beavers should increase in abundance in the theoretical hardwood forest. Deer would be expected to increase as the forest approaches climax, then decrease and stabilize in population after climax is reached. Raccoons and opossums would probably also increase, but slightly. The rodent population should convert from largely openland to woodland species. The elimination of pastures and other agricultural openings should also cause a change in rabbit species distribution. Lowery (1974) stated that cottontail rabbits are most frequently found in open country and that swamp rabbits are prevalent in woodlands and swamps. Therefore, the swamp rabbit should become the principal rabbit species in the Study Area.

(b) Avifauna.

Turkeys and various passerines should benefit the most from land returned to climax vegetation. Waterfowl, particularly wood ducks, should seasonally become very abundant in flooded bottomland hardwoods. Birds dependent on agriculture, such as starlings, grackles, various shorebirds and hawks should decrease in abundance as the vegetation reached climax conditions.

(c) Herpetofauna.

Most reptiles and amphibians are expected to become more numerous in the climax forest because of increased habitat.

(d) Invertebrates.

Climax vegetation is expected to decrease the biomass of invertebrates because many agricultural pests will not occur. Many insects such as grasshoppers, leafhoppers, crickets and various dipterans should also decrease in the absence of large grasslands and pastures. However, the climax community would have a greater diversity of invertebrates due to increased niches.

b. Terrestrial Limiting Factors.

(1) Botanical Limiting Factors.

Since the concept of anticipating a potential climax community is based on unrestricted vegetative growth, the principal limiting factors

TABLE VI-5

Potential Carrying Capacities for the More Common Game Species in Hypothetical Climax Forest Types in the Study Area

| WILDLIFE SPECIES | FOREST TYPE | |
|---|---|---|
| | BOTTOMLAND HARDWOODS | UPLAND HARDWOODS |
| White-Tailed Deer (*Odocoileus virgiananus*) | 1 per 20 acres | 1 per 30 acres |
| Squirrels (*Sciurus* spp.) | 1.3 per acre | 1 per 2 acres |
| Rabbits (*Sylvilagus* spp.) | 1.5 - 2 per acre | 1.5 per acre |
| Raccoon (*Procyon lotor*) | 1 per 15 acres | 1 per 20 acres |
| Wild Turkey (*Meleagris gallopavo*) | 1 per 75 acres | 1 per 100 acres |
| Wood Duck (*Aix sponsa*) | 1 per 100 acres | Uncommon visitor |
| Migrant Waterfowl | 1 per 10 acres | Uncommon visitor |

SOURCES: Arkansas Game and Fish Commission, pers. comm.; Noble, pers. comm.; Yancey 1970.

will be species specific. Such factors as light requirements, flooding tolerance and soil characteristics such as texture, internal and surface drainage, and slope will regulate forest composition.

(2) Zoological Limiting Factors.

Composition and distribution of the vegetative species will have a pronounced effect on the fauna of the area. By allowing all vegetation to reach climax conditions, many open areas will be eliminated. The elimination of these areas would influence many animals and would probably be the most limiting factor controlling the density of quail and turkey because open areas provide necessary nest sites for these birds. The exclusion of agricultural and urban areas would restrict the occurence of many rodents, excluding squirrels, and many seed and insect eating birds such as grackles, starlings, swallows and martins. The absence of large openings would also decrease the abundance of many invertebrates such as grasshoppers, leafhoppers, bees and wasps.

Flooding would be expected to be only a temporary limiting factor regulating abundance and distribution of terrestrial fauna. This natural phenomenon would occur primarily along Bayou Bartholomew and would periodically restrict habitation of nearly all game animals, except wood ducks and migrant waterfowl. Overall, animal populations would likely be largely unaffected by periodic inundations.

Another limiting factor in the climax forest would be wildfires. Fires are beneficial in that they maintain or create open habitats in forested areas. Game animals such as rabbits, quail, deer and turkeys would only be temporarily affected by loss of habitat due to wildfires. Animals of the mature forests, such as squirrels and raccoons, would be affected on a long-term basis.

D. THREATENED* NATIVE PLANTS AND ANIMALS.

There is increasing concern for the possible extinction of plant and animal species worldwide. Not only must such species be carefully delineated, but their required habitats for all stages of their life history must be understood and preserved. Several sets of criteria have been assigned to the concepts of endangered, threatened, rare, etc. One such set has been developed by the International Union for the Conservation of Nature and Natural Resources and adopted by many professional groups such as the Flora North America Project, the Conservation Committee of the American Society of Ichthyologists and Herpetologists, and the Endangered Species Committee of the American Fisheries Society:

Endangered - Actively threatened with extinction. Continued survival unlikely without the implementation of special protective measures.

Rare - Not under immediate threat of extinction, but occurring in such small numbers and/or in such restricted or specialized habitats that it could disappear quickly.

* All species which are recognized to be variously endangered by professional societies and the U.S. Department of the Interior.

Depleted - Although still occurring in numbers adequate for survival, the species has been heavily depleted and continues to decline at a rate substantially greater than can be sustained.

Indeterminate - Apparently threatened, but insufficient data is currently available on which to base a reliable assessment of status.

The Endangered Species Act of 1973 (Public Law 95-205) established other status definitions which are employed by the U.S. Department of the Interior's (1974) Fish and Wildlife Service:

Endangered Species - Those species in danger of extinction throughout all or a significant portion of their ranges.

Threatened Species  Any species which is likely to become an endangered species within the forseeable future throughout all or in a significant portion of its range.

Both sets of definitions are used to call attention to species facing potential extinction and listings from both are used in the survey of threatened species of the Study Area which follows. The Endangered-Rare-Depleted terminology is used primarily by individual professional biologists to delineate species whose numbers are declining within a specific geographic area such as Arkansas and often identifies threatened species at a much lower critical level than does Federal identification. Many of these species so identified, however, are not usually protected by legal restrictions and regulations. The U S. Department of the Interior designations, however, are global in scope and consider status from the vantage point of the total species range. Species designated as Endangered or Threatened under the Endangered Species Act have demonstrated serious declines throughout their ranges and species of both categories are protected by many legal restrictions and regulations (Code of Federal Regulations, Title 50, Chapter I, Subchapter B, as well as regulations published subsequently in the Federal Register).

It should also be noted that to date very incomplete surveys have been conducted on threatened invertebrate animals and non-vascular plants. On the other hand, many species now considered rare or undetermined in status may, with careful survey, prove to be much more common than now recognized and/or well able to adapt to the changing environment.

Because of the small size of the Pine Bluff Study Area and in the absence of intensive field work, only those species which have been accorded a threatened designation by either independent professional biologists working within Arkansas or by the U.S. Fish and Wildlife Service are identified. Also, because of the national significance of Endangered and Threatened species delineated by the U.S. Department of the Interior, these species are discussed in more detail than are those identified as threatened for Arkansas alone. For the latter, extensive use has been made of the identification and discussion of threatened species developed by Tucker(1974), Buchanan (1974), Reagan (1974a, 1974b), James (1974) and Sealander and Gibson (1974) for the Arkansas Natural Area Plan.

1. Vascular Plants.

The following account of threatened plants is drawn exclusively from Tucker (1974). With the large number of taxa involved, Federal identification of threatened plant species has been slow to develop. Although the Smithsonian Institute has published a "Report on Endangered and Threatened Plant Species of the United States" (Smithsonian Institute, 1975), the species recognized for Arkansas in that report were not included as threatened species growing in or near the Study Area by Tucker (1974).

a. Hay-scented Fern, *Dennstaedtia punctilobula* (Michx.) Moore.

RANGE AND STATUS OVERALL: Common throughout New England and the southeastern states.

RANGE IN ARKANSAS: The Hay-scented Fern is on the periphery of its range in Arkansas and has been documented only from Magazine Mountain in Logan County and from City Rock Bluff across from Calico Rock, Arkansas. It has been reported from the vicinity of Pine Bluff, but collection records and voucher material are not presently known.

STATUS IN ARKANSAS: Rare.

HABITAT: The Hay-scented Fern is somewhat xerophytic and is commonly encountered on bluffs, rocky slopes and the forest floor of dry woods.

RELATIONSHIP TO STUDY AREA: This fern species may be encountered in the Study Area in the upland and outcrop areas to the west. Some of the ridges and bluffs along the Arkansas River on the U.S. Arsenal may also provide favorable habitat.

b. Corkwood, *Leitneria floridana* Chapman.

RANGE AND STATUS OVERALL: Infrequent in isolated localities in southeast Texas, southeastern Missouri, eastern Arkansas, southern Georgia and northern Florida.

RANGE IN ARKANSAS: The Corkwood is probably more abundant in the Arkansas-Missouri area than anywhere else in the country. In Arkansas, it is abundant in the northeast counties and occurs in scattered localities in the southeast including Jefferson, Arkansas and Lincoln counties.

STATUS IN ARKANSAS: Rare.

HABITAT: The Corkwood is found in poorly drained swamps and ditches.

RELATIONSHIP TO STUDY AREA: This species occurs northeast of the Study Area in the bottomlands of Bayou Meto. Although some seemingly favorable habitat occurs in the Study Area, it is doubtful that the species grows within its boundaries. Corkwood is fairly distinctive and has been looked for repeatedly by both professional and amateur botanists.

c. Woolly Dalea, Dalea lanata Spreng.

RANGE AND OVERALL STATUS: Common from Kansas and Colorado to Texas.

RANGE IN ARKANSAS: The Arkansas populations of Woolly Dalea are scattered and east of the principal distribution range. Sizable populations are located in the Holla Bend National Wildlife Refuge, Pope County and Jefferson County.

STATUS IN ARKANSAS: Undetermined.

HABITAT: The Woolly Dalea is most commonly encountered on dry sandy soils of disturbed areas.

RELATIONSHIP TO STUDY AREA: Populations of Woolly Dalea occur on Boyd Point and on the sandy disturbed soils of the Pine Bluff port area.

d. Devil's Bit, Chamaelirium luteum (L.) Gray.

RANGE AND STATUS OVERALL: Scattered localities throughout the southeastern United States; status is unknown.

RANGE IN ARKANSAS: In Arkansas, Devil's Bit is found in scattered localities in Saline, Bradley, Paulaski, Hot Spring and Jefferson counties.

STATUS IN ARKANSAS: Rare and Endangered.

HABITAT: The Devil's Bit is found most commonly in rich, mesic wooded slopes and coves.

RELATIONSHIP TO STUDY AREA: Within the Study Area, Devil's Bit has been encountered only in one locality: along the north boundary road of the U.S. Arsenal in the vicinity of Eastwood Bayou.

e. Yellow Lady-slipper, Cypripedium calceolus L. var pubescens (Willd.)Correll.

RANGE AND STATUS OVERALL: Widespread from Quebec south to Georgia, west to New Mexico, Washington, British Columbia and the Yukon Territory; status, unknown.

RANGE IN ARKANSAS: The Yellow Lady-slipper occurs throughout the mountain counties and in scattered localities on the Coastal Plain.

STATUS IN ARKANSAS: Rare, depleted in some areas.

HABITAT: This orchid species occurs in a variety of wooded habitats throughout its range.

RELATIONSHIP TO STUDY AREA: The Yellow Lady-slipper has been collected only infrequently within the Study Area along the north boundary road of the U.S. Arsenal in the vicinity of Eastwood Bayou.

2. Fishes (Buchanan, 1974).

a. Shovelnose Sturgeon, *Scaphirhynchus platorynchus* (Rafinesque).

RANGE AND STATUS OVERALL: The Shovelnose Sturgeon is found in the Missouri, Ohio, and Mississippi river valleys from Montana eastward to Ohio and western Pennsylvania, excluding the Great Lakes Basin, and southward to northern Alabama and Texas. Its status is depleted, as it has significantly decreased in abundance over most of its range since 1900, especially in the Mississippi River.

RANGE IN ARKANSAS: Confined to the larger rivers of the state; it has been collected from the Mississippi, White, Black, Arkansas, Spring and Red rivers.

STATUS IN ARKANSAS: Endangered (Depleted).

HABITAT AND LIFE HISTORY: The Shovelnose Sturgeon inhabits the bottom of large rivers, most often over firm, sandy bottoms in channels where the current is strong. It is a bottom feeder and spawns in the early spring, migrating into smaller tributary channels (Cross,1967). Dams and channel restrictions which have altered the habitat and interferred with migration, alteration of spawning areas, and heavy commercial fishing in the early part of the century are responsible for the decline of the species (Cross,1967).

RELATIONSHIP TO STUDY AREA: Within the Study Area, the Shovelnose Sturgeon may be found in the Arkansas River, although todate there are no documented records. It is possible that some of the small tributaries such as Tulley and Phillips creeks which drain the U.S. Arsenal could serve as spawning areas.

b. Paddlefish, *Polyodon spathula* (Walbaum).

RANGE AND STATUS OVERALL: The Paddlefish ranges from the Missouri and Mississippi river valleys from Montana eastward to the Great Lakes region and southward to southern Alabama and southeastern Texas. Throughout all of its range, it is depleted.

RANGE IN ARKANSAS: The Paddlefish has been collected frequently in the larger rivers (Arkansas, Mississippi, Red and White) and occasionally in their smaller tributaries.

STATUS IN ARKANSAS: Endangered (Depleted).

HABITAT AND LIFE HISTORY: The Paddlefish inhabits pools and backwater areas of larger rivers where the bottoms are silty and the current is slow or absent. It is also found occasionally in the larger oxbow lakes and bayous. The Paddlefish is principally a bottom feeder and it migrates to clear, swift tributaries to spawn. Decline of this species is attributed to destruction of spawning grounds, blockage of spawning migrations and overfishing. However, the Paddlefish thrives

in man-made impoundments provided they have large tributaries for spawning (Pflieger, 1971), and impoundments such as on the Arkansas River may provide for expansion of Paddlefish populations.

RELATIONSHIP TO STUDY AREA: Although records are absent, the Paddlefish could inhabit the backwater areas of the Arkansas River near Pine Bluff such as Lake Langhofer and the backwater areas created by the Hensley Bar Cutoff. With sufficient flow, small fast moving tributaries such as Tulley and Phillips creeks could provide suitable spawning grounds.

c. Alligator Gar, *Lepisosteus spatula* Lacepede.

RANGE AND STATUS OVERALL: The Alligator Gar is found in the Mississippi River and its larger tributaries, the Missouri and Ohio rivers, from southern Missouri, Illinois and Ohio, southward to the Gulf of Mexico in northern Florida and northern Mexico. It is depleted over much of its range and in some areas is rare.

RANGE IN ARKANSAS: Collected from the Mississippi, Red, Arkansas, and lower Ouachita rivers. Also found in larger oxbow lakes and bayous.

STATUS IN ARKANSAS: Endangered (Depleted and Rare).

HABITAT AND LIFE HISTORY: The Alligator Gar inhabits the sluggish portions of large, warm, lowland rivers, bayous and oxbow lakes where it feeds chiefly on shad and minnows. Spawning occurs in late spring without migration. Decline of the Alligator Gar is attributed to the channelization of streams in lowland areas, the clearing of watersheds, and the heavy commercial and sport fishing.

RELATIONSHIP TO STUDY AREA: Within the Study Area, the Alligator Gar could be present in the backwater areas of the Arkansas River such as Lake Langhofer and in associated lowland streams such as Bayou Bartholomew.

d. Plains Minnow, *Hybognathus placitus* Girard.

RANGE AND STATUS OVERALL: The Plains Minnow is found in the Great Plains drainages from Montana south to New Mexico and Texas and eastward to Missouri and Arkansas. It is common throughout most of its range.

RANGE IN ARKANSAS: Arkansas represents the eastern edge of the range of the Plains Minnow. It is a large-river fish which has been found in the mainstreams of the Mississippi, Arkansas and Red rivers. However, no collections have been made since 1940.

STATUS IN ARKANSAS: Rare.

HABITAT AND LIFE HISTORY: The Plains Minnow is found mainly in large, turbid rivers where sand and silt sediments accumulate in shallow backwaters with some current (Cross, 1967). It is herbivorous, feeding on algae that accumulate on the bottom. Eggs seem to be scattered over the substrate without nest sites or territories. The breeding season appears to be long, extending from spring to late summer (Cross, 1967).

RELATIONSHIP TO STUDY AREA: Although no collection records are available, the Plains Minnow could be found in the Study Area in the Arkansas River where sediments accumulate.

e. Ironcolor Shiner, Notropis chalybaeus (Cope)

RANGE AND OVERALL STATUS: The Ironcolor Shiner is found throughout the drainages of the Coastal Plains lowlands from New Jersey to Texas and up the Mississippi Valley to Michigan and Wisconsin. It is common over most of its range, but rare in peripheral areas such as Arkansas.

RANGE IN ARKANSAS: Scattered records from bayous in Monroe, Columbia and Jefferson counties.

STATUS IN ARKANSAS: Rare

HABITAT AND LIFE HISTORY: The Ironcolor Shiner is a lowland species occurring in relatively clear bayous, streams and backwater areas having bottoms of mud, clay, dead organic matter and abundant aquatic vegetation. It feeds on detritus and algae and breeds throughout the summer. Decline in Arkansas is attributed to loss of habitat through channelization and increased sedimentation.

RELATIONSHIP TO STUDY AREA: The Ironcolor Shiner was collected in a rotenone set at Station 5 (Bayou Bartholomew at Pinebergen). Considering its habitat requirements, it could be found throughout Bayou Bartholomew and in the upper reaches of Caney Bayou.

f. Taillight Shiner, Notropis maculatus (Hay).

RANGE AND OVERALL STATUS: The Taillight Shiner is found on the Coastal Plains lowlands, from southeastern Missouri in the north, to eastern Texas and southeastern Oklahoma in the west, to the Gulf of Mexico and the Atlantic Coast of North Carolina in the east. It is common throughout most of its range, but rare in peripheral areas.

RANGE IN ARKANSAS: Scattered records of the Taillight Shiner occur in the eastern portions of the State including Grant, Jefferson and Arkansas counties.

STATUS IN ARKANSAS: Rare

HABITAT AND LIFE HISTORY: The Taillight Shiner is a lowland species found in bayous, backwater areas and oxbow lakes. It feeds on detritus and algae and breeds throughout the summer. Its numbers are assumed to have declined in Arkansas as a result of channelization and sedimentation of bayous on the Coastal and Alluvial plains.

RELATIONSHIP TO STUDY AREA: This species was collected at stations 1 and 3 on Bayou Bartholomew (Princeton Pike Road and Highway 15, respectively), and were the first collections reported from Jefferson County. It could well be found throughout Bayou Bartholomew and the upper reaches of Caney Bayou.

g. Cypress Minnow, Hybognathus hayi Jordan.

RANGE AND OVERALL STATUS: The Cypress Minnow is a lowland species from Illinois to northeast Texas and eastward to western Florida. It is common.

RANGE IN ARKANSAS: The Cypress Minnow was formally known from throughout the Coastal Plains lowlands of Arkansas, but recent collections indicate a more scattered distribution.

STATUS IN ARKANSAS: Undetermined, possibly endangered.

HABITAT AND LIFE HISTORY: The Cypress Minnow inhabits slow moving bayous, swamps and backwater areas. It is most commonly encountered where there is abundant streamside vegetation, an absence of current and a silty, soft bottom. It is seldom found within the main channel. The Cypress Minnow feeds on detritus and algae and breeds during the summer months. It is presumed to have declined in Arkansas with a loss of favorable habitat.

RELATIONSHIP TO STUDY AREA: Cypress Minnows were common in the Study Area and were collected at stations 1 and 3 on Bayou Bartholomew and at Station 7 on Caney Bayou.

h. Starhead Topminnow, Fundulus notti (Agassiz).

RANGE AND OVERALL STATUS: The Starhead Topminnow ranges from Iowa to Ohio and South Carolina and south to Florida and Texas. It is common, but declining in numbers throughout its range.

RANGE IN ARKANSAS: This species ranges throughout the Alluvial and Coastal Plains and in the foothills of the Ouachita Mountains.

STATUS IN ARKANSAS: Undetermined, possibly endangered.

HABITAT AND LIFE HISTORY: The Starhead Topminnow occurs in weedy, shallow and quiet waters of bayous, backwater areas and swamps. It feeds on small surface insects, crustaceans and various larvae and breeds throughout the summer months. Eggs are deposited on aquatic vegetation. Although common in Arkansas, its numbers may be declining with loss of habitat and thus should be placed in an undetermined status until more definite data are available.

RELATIONSHIP TO STUDY AREA: The Starhead Topminnow was collected at Station 3 (Bayou Bartholomew at Highway 15). The extensive growth of alligatorweed undoubtedly makes excellent cover and reproductive areas for this species.

i. Dollar Sunfish, Lepomis marginatus (Holbrook).

RANGE AND OVERALL STATUS: The Dollar Sunfish is more restrictive in its distribution than most sunfishes. It occurs in the lower Mississippi Valley from southeastern Oklahoma to Tennessee and from Texas to Florida and northward to South Carolina. It is uncommon, but not threatened.

RANGE IN ARKANSAS: This species is found in scattered localities thoughout the lowlands of the State, where it reaches the northwestern limits of its range.

STATUS IN ARKANSAS: Undetermined, possibly endangered.

HABITAT AND LIFE HISTORY: The Dollar Sunfish occurs in sluggish creeks, bayous and backwaters of rivers. Typically, the species will occupy habitats near the waters edge where they are afforded protection by streamside vegetation. The Dollar Sunfish feeds mainly on insects. Reproduction occurs throughout the warmer months, but most intensively in the late spring. Nests are made and defended by the males in shallow shoreline areas. Although undocumented, this naturally uncommon sunfish is thought to be declining in numbers with channel-ization and other alterations to its native streams.

RELATIONSHIP TO STUDY AREA: The Dollar Sunfish is common in the Study Area and was collected at stations 1, 3 and 5 on Bayou Bartholomew and at station 7 on Caney Bayou.

j. Swamp Darter, *Etheostoma fusiforme* (Girard).

RANGE AND OVERALL STATUS: The Swamp Darter is a lowland species wide-spread in the coastal drainages below the fall line from southern Maine to Louisiana and northward into Oklahoma, Arkansas and Tennessee. It is abundant in coastal streams, but becoming less so inland, although currently not considered threatened throughout its range.

RANGE IN ARKANSAS: The Swamp Darter is known from scattered localities in the southeastern and eastern portions of Arkansas: oxbows in St. Francis County, backwater areas in Calhoun County and bayous in Monroe, Arkansas and Jefferson counties.

STATUS IN ARKANSAS: Rare.

HABITAT AND LIFE HISTORY: The Swamp Darter seems to occupy a range of habitats from typical swamp areas of old oxbow lakes, to clear lakes with aquatic vegetation. It prefers areas where the bottom is muddy and covered with decaying organic matter. It seems to thrive only where there is sufficient vegetation for cover and reproduction. The Swamp Darter typically resides near the bottom of streams feeding on benthic invertebrates. Spawning occurs in the warmer months and the eggs are deposited in sand or gravel areas where they hatch un-attended.

RELATIONSHIP TO STUDY AREA: The Swamp Darter was collected in Bayou Bartholomew at Station 1 (Princeton Pike Road) and this is the first reported collection for Jefferson County. The habitat of this station is not typical for the Swamp Darter in that that reach of the bayou is somewhat ephemeral. There is, however, streamside vegetation, organic debris, and sandy-gravelly areas typical of Swamp Darter habitats. The Swamp Darter could also be encountered in Caney Bayou, and in oxbow lakes and sloughs such as Byrd Lake and Bayou Imbeau.

3. Amphibians and Reptiles (Reagan, 1974).

a. Mole Salamander, Ambystoma talpoideum.

RANGE AND STATUS OVERALL: The Mole Salamander occurs from the Coastal Plains of South Carolina to central Florida and west to Texas and north in the Mississippi Alluvial Plain to southern Illinois and Missouri. It is relatively common.

RANGE IN ARKANSAS: The Mole Salamander has been collected only once in Arkansas from Clay County. However, because it is a burrowing species and difficult to detect, it may be found throughout the Mississippi Alluvial Plain.

STATUS IN ARKANSAS: Rare.

HABITAT: Little specific habitat or life history information currently exists for the Mole Salamander. It is a burrowing species, but it may also be encountered beneath fallen logs or rocks near ponds where it breeds in the spring. In the lowland, it is usually associated with wooded areas.

RELATIONSHIP TO STUDY AREA: The Mole Salamander has not been collected in the Study Area or in Jefferson County. However, given its widespread distribution, it may well occur in isolated wooded areas on the Alluvial Plain.

b. American Alligator, Alligator mississippiensis.

RANGE AND STATUS OVERALL: The Alligator ranges from the Atlantic coastal plains of North Carolina, throughout Florida and along the coastal plain of the Gulf of Mexico to the Rio Grande River in Texas. It is limited to relatively inacessable coastal lowlands with adequate moisture. The Alligator is listed by the Fish and Wildlife Service (U.S. Department of Interior, 1974) as endangered.

RANGE IN ARKANSAS: There is one breeding population of Alligators in Arkansas at Grassy Lake in Hempstead County. The species once ranged throughout the eastern portions of the State, but all confirmed reports are from the vicinity of the breeding area.

STATUS IN ARKANSAS: Endangered.

HABITAT AND LIFE HISTORY: Alligators inhabit quiet waters such as swamps, marshes, bayous and small lakes and utilize masses of floating or shoreline vegetation for nest construction and basking sites. Nests built in the spring are typically constructed as cones on elevated ground and require extensive amounts of herbaceous vegetation. Approximately 40 eggs are deposited and covered within the cone and hatching requires approximately 60 days. Unsuccessful hatching most often results from predation by raccoons, high water or exposure of the eggs to sunlight. The adult Alligators feed on fish, snakes, turtles and waterfowl. They are limited to areas of adequate moisture

and relatively warm temperatures. Throughout their range, they have declined due to hunting pressures and loss of suitable habitat. Although in certain portions of Louisiana and Florida they are increasing in number, with the continued loss of wetland habitats, it is doubtful that they will ever again become a common species in other portions of their range.

RELATIONSHIP TO STUDY AREA: There have been two unconfirmed reports of the presence of the Alligator within the Study Area: one at Blackdog Lake and the other west of Highway 15 along Bayou Bartholomew. Although the Study Area represents the more northern portions of the Alligator's range, there are numerous areas where, if protected, the Alligator could build suitable populations. Such areas include the backwater areas along Lake Langhofer (in the vicinity of Blackdog Lake), Bayou Bartholomew in its more isolated reaches, Byrd Lake and several isolated oxbow lakes and sloughs with adequate vegetation.

4. Birds (James, 1974).

In the following account of threatened bird species, only those birds which are known to breed within the Study Area or are winter residents are discussed; threatened birds only occassionally seen within the Study Area or migrants are not discussed. Endangered birds designated by the U.S. Department of Interior (1974) are discussed first (a through c) followed by a brief accounting of threatened Arkansas birds (d through v).

a. Bald Eagle, *Haliaeetus leucocephalus*.

RANGE AND STATUS OVERALL; The Bald Eagle occurs in North America north of Mexico and in northeastern Siberia. Two subspecies have been described for the Bald Eagle: *H.l. leucocephalus*, the Southern Bald Eagle and *H.l. alascanus*, the Northern Bald Eagle. Only the former has been designated as endangered by the U.S. Department of Interior (1974). However, under the Endangered Species Act of 1973, there is provision for protection of closely related species or subspecies and hence justification for treating the Bald Eagle here as a single taxonomic unit. The southern subspecies breeds from the Gulf states north to the Carolinas.

RANGE IN ARKANSAS: In Arkansas, the Southern Bald Eagle has long been extirpated as a breeding species and possibly also as a winter resident. It once nested in several Arkansas Counties including Jefferson County, but all recent records have been in the winter and most are probably Northern Bald Eagles which have migrated south for the winter. It is not impossible, however, for these sightings to have included Southern Bald Eagles which have flown north from Florida or elsewhere. Winter records appear to be increasing, but the reason for this is uncertain.

STATUS IN ARKANSAS: Rare winter resident.

HABITAT REQUIREMENTS: Feeding primarily on fish, the Bald Eagle occupies a variety of forest communities near major waterways. Nests

are usually constructed from sticks in large trees, and mating occurs in the late fall. The young remain in the nest for periods up to three months and require four to five years to reach maturity. After the young are reared, the Bald Eagle ranges many hundreds of miles from its nesting site, but instinctively returns to breed. Mature birds preferentially breed where they were reared and the absence of extant breeding pairs in Arkansas may be the result of the destruction of the native bird populations by people deliberating hunting them as pests and for sport. Their decline can also be attributed to a loss of habitat. Although habitat requisites for breeding still exist both in Arkansas and in the Study Area (lower reaches of Bayou Bartholomew, scattered tracts of bottomland forest and other similar areas), the habitat is neither isolated nor continuous, both of which appear to be prerequisites for successful breeding. Lastly, the Bald Eagle is a top predator in the food web, and, as such, concentrates many potential toxins (pesticide residues and heavy metals).

RELATIONSHIP TO STUDY AREA: During the winter months, the Bald Eagle is sighted along the river, over Yellow Lake, and on the lower reaches of Bayou Bartholomew. For the past several years these sightings have increased. Whether this is a reflection of increased abundance, increased observers, or both is not known.

b. Peregrine Falcon, *Falco peregrinus*.

RANGE AND STATUS OVERALL: The range of the Peregrine Falcon is world-wide. In the United States, it occurs from the Artic, south to northern Georgia and Louisiana. It is endangered.

RANGE IN ARKANSAS: The only nesting site of this bird in Arkansas was recorded in Cleburne County during the early part of the century. Today it is an uncommon winter resident and is only rarely seen within the Study Area.

STATUS IN ARKANSAS: Endangered, no longer breeding in Arkansas.

HABITAT REQUIREMENTS: The Peregrine Falcon feeds primarily on other birds, particularly waterbirds: ducks and wading birds that congregate along the coast and inland waterways. It nests usually in snags or rocky ledges in close proximity to water. Its decline has been attributed primarily to the accumulation of chlorinated hydrocarbon residues which interfere with its reproductive physiology. However, as populations of the Peregrine Falcon have reportedly been on the decline since the turn of the century, other factors such as loss of habitat and/or natural extinction may be also playing a role in the decline of this species.

RELATIONSHIP TO STUDY AREA: There is only one documented record of a Peregrine Falcon within the Study Area, along the Arkansas River. Given the paucity of breeding records in Arkansas and the bird's current endangered status, it is doubtful that the Study Area will ever be a breeding area for the Peregrine Falcon.

c. Red-cockaded Woodpecker, Dendrocopos borealis.

RANGE AND OVERALL STATUS: The Red-cockaded Woodpecker occurs in the southeastern United States, north to southeast Virginia, western Kentucky, Tennessee, southern Missouri and eastern Oklahoma. It is endangered.

RANGE IN ARKANSAS: The Red-cockaded Woodpecker is seen in scattered localities throughout the state and breeds in selected localities south and west of the Arkansas River in both the West Gulf Coastal Plain and the Oauchita Mountains. The most viable breeding sites in Arkansas are in the mature pine stands of Ashley and Hempstead counties.

STATUS IN ARKANSAS: Endangered.

HABITAT REQUIREMENTS: The Red-cockaded Woodpecker resides primarily in mature southern pine forests. In Arkansas, it occurs principally in loblolly pine (Pinus taeda) and may occasionally be found in old stands of shortleaf pine (Pinus echinata). Colonies of the Red-cockaded Woodpecker nest in cavities excavated in very mature live trees (50-75 year in age, Louisiana Wildlife & Fisheries Commission, pers. comm.). The cavities are used for several years, but as trees die or food resources become diminished, the colony moves. As a consequence, continued residency within a given area requires a relatively large stand of suitable trees. The decline of the Red-cockaded Woodpecker is attributed primarily to a loss of suitable habitat due to even-aged pine forest management practices: the harvesting of trees by both private individuals and lumber companies before they attain the maturity required by the Red-cockaded Woodpecker.

RELATIONSHIP TO STUDY AREA: Small colonies of Red-cockaded Woodpeckers once nested on the Pine Bluff Arsenal and in stands of mature pines in what is now the Jefferson Industrial Park. Today these colonies (or perhaps a single colony) have been completely extirpated and only their silent burrows remain as a legacy. A small stand of pines of suitable maturity existed in the vicinity of Watson Chapel, but was recently harvested. Although several old shortleaf pines are still found in the Study Area (Sulphur Springs Fire Tower Road and in the vicinity of Camp Ta-Lo-Ha), it is doubtful that they are of sufficient extent to attract the Red-cockaded Woodpecker and, to date there are no recorded sightings from these areas.

d. Double-crested Cormorant, Phalacrocorax auritus.

RANGE AND OVERALL STATUS: The Double-crested Cormorant breeds locally from James Bay and the Gulf of St. Laurence, south to Florida and the Gulf of Mexico (Bahama Islands and Cuba) and winters mostly along the southern coasts (Peterson, 1947). Its status is unknown.

RANGE IN ARKANSAS: Originally common in the rivers and swamps of eastern Arkansas, most of the populations were extirpated as early as 1910. The birds used to nest in vast rookeries, the last of which was recorded for the state in 1951 at Grassy Lake in Hempstead County.

STATUS IN ARKANSAS: Uncommon winter resident, no longer breeding in state.

HABITAT REQUIREMENTS: As a winter resident, the Double-crested Cormorant inhabits the more remote swamps and bottomland areas where it feeds on small fishes. Nesting areas require the same habitat. As seemingly favorable habitat still exists in Arkansas and in the Study Area, although scattered, the decline of the Double-crested Cormorant may be attributed to the loss of extensive and continuous habitat as well as other factors.

RELATIONSHIP TO STUDY AREA: Winter sightings in the Study Area are rare. The Double-crested Cormorant has been seen on Lake Pine Bluff and on the Arkansas River.

e. Pied-Billed Grebe, *Podilymbus podiceps*.

RANGE AND OVERALL STATUS: The Pied-billed Grebe ranges throughout the United States and southern Canada, and southward to southern South America. Its status is stable.

RANGE IN ARKANSAS: This bird is found regularly in the fall, winter and spring on open water; breeding populations are reported from scattered counties including Jefferson, Lonoke, Woodruff, Critterden and Desha.

STATUS IN ARKANSAS: Endangered as a breeding bird.

HABITAT REQUIREMENTS: Shallow marshes having emergent vegetation and areas of open water.

RELATIONSHIP TO STUDY AREA: The Pied-billed Grebe is uncommon in the Study Area, but breeding records include a managed slough near the Pine Bluff Port. It may occur in other places where the appropriate marsh-like habitat occurs.

f. Anhinga, *Anhinga anhinga*.

RANGE AND OVERALL STATUS: The Anhinga breeds from North Carolina to Arkansas and winters along the southern Atlantic and Gulf coasts and in Central America. Its status is common.

RANGE IN ARKANSAS: Although the Anhinga at one time nested in numbers at Swan Lake in eastern Jefferson County, today it nests only at Grassy Lake in Hempstead County and possibly in the White River National Wildlife Refuge. The Anhinga is uncommon during the winter months.

STATUS IN ARKANSAS: Endangered as a breeding bird.

HABITAT REQUIREMENTS: Whether overwintering or nesting, the Anhinga prefers isolated swamps and feeds principally on small fishes. Breeding begins in late March or early April.

RELATIONSHIP TO STUDY AREA: Today the Anhinga is rare in the Study Area. In recent years, the Anhinga has been sighted at the Arsenal near the bluffs on the Arkansas River.

g. Great Blue Heron, *Ardea herodias*.

RANGE AND OVERALL STATUS: The Great Blue Heron breeds from the Florida Keys and the Gulf Coast north to Nova Scotia and west to Manitoba. It winters primarily in the southern United States and in Central America and is common throughout most of its range.

RANGE IN ARKANSAS: The Great Blue Heron is found throughout Arkansas and is threatened as a breeding bird in many parts of the State where there has been extensive drainage of wet areas and associated woodlands.

STATUS IN ARKANSAS: Threatened as a breeding bird.

HABITAT REQUIREMENTS: The Great Blue Heron requires rivers, lakes or reservoirs for feeding areas where it feeds on small fishes and bottom dwelling invertebrates, and uses nearby trees for nesting.

RELATIONSHIP TO STUDY AREA: The Great Blue Heron is still relatively common in the Study Area, but is rare as a breeding bird.

h. Little Blue Heron, *Florida caerulea*.

RANGE AND OVERALL STATUS: The Little Blue Heron breeds in the southern United States north to New Jersey and winters mainly south of the 30° North Latitude. Its status is unknown.

RANGE IN ARKANSAS: This bird nests in scattered localities on the Alluvial and Coastal plains of eastern and southern Arkansas.

STATUS IN ARKANSAS: Threatened as a breeding bird.

HABITAT REQUIREMENTS: The Little Blue Heron uses ponds, lakes or shallow reservoirs for feeding areas and thickets of trees over land for nesting areas.

RELATIONSHIP TO STUDY AREA: A large colony of Little Blue Herons at Swan Lake was abandoned in the 1950's. The species is no longer known to breed in the Study Area. It is seen frequently near Lake Pine Bluff, Bayou Bartholomew, the Arkansas River and other water courses following breeding.

i. Great Egret, Casmerodium albus.

RANGE AND OVERALL STATUS: The range of the Great Egret is nearly world-wide; North American birds winter mainly south of the 40° North Latitude. The status of the species is unknown.

RANGE IN ARKANSAS: The Great Egret is seen throughout Arkansas and nests in the eastern and southern sections.

STATUS IN ARKANSAS: Threatened as a breeding bird.

HABITAT REQUIREMENTS: The Great Egret prefers shallow marshes and lakes with a mixture of open water and emergent vegetation and nests in colonies in small trees.

RELATIONSHIP TO STUDY AREA: The Study Area may contain small breeding colonies. The birds are most commonly seen in the spring and fall.

j. Snowy Egret, Egretta thula.

RANGE AND OVERALL STATUS: The Snowy Egret breeds throughout most of the United States and southward through South America; it winters from California to South Carolina southward.

RANGE IN ARKANSAS: The Snowy Egret is sighted throughout Arkansas, but breeds only in the lowlands of the eastern and southern sections of the State.

STATUS IN ARKANSAS: Threatened as a breeding species.

HABITAT REQUIREMENTS: The Snowy Egret requires marshlands, shallow lakes and reservoirs having some emergent vegetation and nests in colonies in nearby trees and shrubs.

RELATIONSHIP TO STUDY AREA; The Snowy Egret is not known to nest in the Study Area, but it may possibly be seen near the lakes in the Study Area.

k. Yellow-Crowned Night Heron, Nyctanassa violacea.

RANGE AND OVERALL STATUS: The Yellow-crowned Night Heron ranges from the southwestern to the northeastern United States and south to northern South America. It winters from the southern United States southward.

RANGE IN ARKANSAS: The Yellow-crowned Night Heron breeds throughout Arkansas in small numbers; it is rarely seen in winter.

STATUS IN ARKANSAS: Threatened as a breeding species.

HABITAT REQUIREMENTS: This species occupies bottomland forests near rivers and feeds in the shallows along rivers, in open wetlands and in wet pastures.

RELATIONSHIP TO STUDY AREA: This species was once common on Bayou Bartholomew, but is now less frequent due to the clearing of the floodplain. It breeds south of Byrd Lake, but is seldom observed breeding elsewhere because of extensive clearing and urbanization.

l. Least Bittern, Ixobrychus exilis.

RANGE AND OVERALL STATUS: The Least Bittern breeds from the northern United States south to central South America and winters from southern Texas to central Florida south. This species is declining.

RANGE IN ARKANSAS: The Least Bittern is seen throughout the state, but is common in the eastern and southern sections. It breeds regularly at Grassey Lake (Hempstead County), and individual nesting sites have been found in several other areas.

STATUS IN ARKANSAS: Endangered as a breeding bird.

HABITAT REQUIREMENTS: The Least Bittern requires dense emergent vegetation in standing shallow water.

RELATIONSHIP TO STUDY AREA: The Least Bittern once nested on Lake Pine Bluff (one record). Perhaps isolated nests may occur on Bayou Bartholomew and near the Arkansas River.

m. Hooded Merganser, Lophodytes cucullatus.

RANGE AND OVERALL STATUS: The Hooded Merganser breeds from southern Canada south to very locally or rarely in the southern states. It winters from the Gulf of Mexico north to southern New England and the Great Lakes. Its status is stable.

RANGE IN ARKANSAS: The Hooded Merganser is not uncommon in migration, but is a rare breeding bird in the swamps and swamp-like habitats of the Mississippi Alluvial Plain.

STATUS IN ARKANSAS: Rare as a breeding bird.

HABITAT REQUIREMENTS: It requires forests having adjacent waterbodies (in Arkansas, bottomland forests adjacent to lakes and sloughs).

RELATIONSHIP TO STUDY AREA: The Hooded Merganser breeds in wood duck boxes on the Pine Bluff Arsenal and perhaps elsewhere such as in the bottomland forest on Boyd Point and scattered forest communities along the Arkansas River.

n. Sharp-Shinned Hawk, Accipter striatus.

RANGE AND OVERALL STATUS: The Sharp-shinned Hawk breeds from northern Florida and the Gulf Coast north to tree limit in Canada. It winters from the northern United States southward to Panama. Its status is unknown.

RANGE IN ARKANSAS: It is infrequently observed during winter residency or in migration and is no longer breeding in Arkansas.

STATUS IN ARKANSAS: Absent as a breeding species; status as a migrant or winter resident unknown, but probably depleted.

HABITAT REQUIREMENTS: It prefers forest communities associated with open areas (fallow fields, croplands, etc.), or waterways and feeds on small birds. Large trees are required for nesting.

RELATIONSHIP TO STUDY AREA: The Sharp-shinned Hawk is infrequently seen throughout the Study Area during the winter. Given its limited breeding history in Arkansas, it is doubtful that this hawk has bred or even will breed in the study area, and winter abundance will decline further as more forest is cleared.

o. Red-shouldered Hawk, Buteo lineatur.

RANGE AND OVERALL STATUS: The Red-shouldered Hawk breeds from southeastern Canada to Florida and in the Gulf states. It winters from the central United States southward and is declining in abundance.

RANGE IN ARKANSAS: It is a permanent resident breeding throughout the state, but most common in the lowlying eastern and southern sections of Arkansas.

STATUS IN ARKANSAS: Threatened as a breeding bird and declining overall.

HABITAT REQUIREMENTS: It prefers mature forest communities, especially bottomland hardwoods and nests in old trees.

RELATIONSHIP TO STUDY AREA: The Red-shouldered Hawk is seen throughout the year and is often observed in forested protions of the Study Area. It has virtually disappeared from much of its former habitat as forested land (particularly bottomland) has been cleared.

p. Marsh Hawk, Circus cyaneus.

RANGE AND OVERALL STATUS: The range of the Marsh Hawk is circumpolar. In the United States, its breeding range extends from the northern boundary south to New Mexico and east to Virginia. The Marsh Hawk winters south to northern South America. Its status is unknown.

RANGE IN ARKANSAS: It is commonly observed in winter and in migration. No current breeding areas are known.

STATUS IN ARKANSAS: Absent as a breeding species; common, but declining, as a winter resident.

HABITAT REQUIREMENTS: It prefers wooded areas, particularly bottomland hardwoods, adjacent to fallow fields and croplands and has a diet mainly of small rodents.

RELATIONSHIP TO STUDY AREA: The Marsh Hawk is commonly seen in winter and observed frequently near Bayou Bartholomew and in open fallow fields on the delta. It has probably increased in the Study Area as bottomland forest has been cleared.

q. Osprey, Pandion haliaetus.

RANGE AND OVERALL STATUS: The Osprey breeds near water from the Gulf of Mexico northward to southern Canada. It winters form the Gulf states southward. Its status is undetermined, but declining.

RANGE IN ARKANSAS: It is observed in small numbers near major waterways during spring and fall migration.

STATUS IN ARKANSAS: Absent as a breeding species.

HABITAT REQUIREMENTS: The Osprey nests typically in old snags, large trees and bluffs immediately adjacent to major lakes and rivers. As a fish eater, it is dependent on stable fish populations for its survival. The recent decline in the Osprey throughout its range is attributed largely to reduced reproductive success due to the presence of chlorinated hydrocarbons and their derivatives in the eggs and nestlings (Amer and Mersereau, 1964). The Osprey may soon be listed as endangered by the U.S. Department of the Interior (U.S. Fish and Wildlife Service, pers. comm.).

RELATIONSHIP TO STUDY AREA: The Osprey has been seen with increasing frequency on Lake Pine Bluff, Yellow Lake and on the Arkansas River. Resident amateur ornithologists report that over the past several years it has arrived in the Study Area sooner and remained longer than in past years. There is breeding habitat along many of the Study Area's waterways and lakes and nesting might possible occur in the future.

r. Purple Gallinule Porphyrula martinica.

RANGE AND OVERALL STATUS: The Purple Gallinule breeds from Florida to Texas and north to South Carolina and Arkansas. It winters from the Gulf Coast to South America and is declining in the southern states.

RANGE IN ARKANSAS: On the northern edge of its range, the Purple Gallinule was formerly common locally in the low wetlands of eastern and central Arkansas.

STATUS IN ARKANSAS: Endangered as a breeding species, uncommon.

HABITAT REQUIREMENTS: It prefers shallow marshes with open water, tall weeds and floating vegetation; nests are constructed commonly of cattails. The bird may also utilize abandoned rice fields.

RELATIONSHIP TO STUDY AREA: The Purple Gallinule is uncommon in the spring during migration in the less disturbed agricultural areas near Bayou Bartholomew. Breeding was documented in 1976 on a borrow pit adjacent to a reservoir near the International Paper Mill.

s. Barn Owl, Tyto alba.

RANGE AND OVERALL STATUS: The Barn Owl occurs in Massachusetts, Ohio, southern Wisconsin and Nebraska and south to the Gulf of Mexico. Its status is undetermined.

RANGE IN ARKANSAS: Rare and widely scattered throughout Arkansas.

STATUS IN ARKANSAS: Endangered as a breeding bird; permanent resident.

HABITAT REQUIREMENTS: Formerly nesting in hollow trees, the Barn Owl now most frequently resides in old abandoned dwellings, barns, and attics. it feeds mainly on small rodents and snakes.

RELATIONSHIP TO STUDY AREA: The Barn Owl is rare in the Study Area where its occurrence has been documented only twice.

t. Willow Flycatcher, *Empidonax traillii*.

RANGE AND OVERALL STATUS: The Willow Flycatcher breeds from northern Canada to central Arkansas and east to northern New Jersey and to Baja California. It migrates through the Mississippi Valley to Central America and is considered stable.

RANGE IN ARKANSAS: It is limited to a single grove on the Grand Prairie in eastern Arkansas and isolated from the main breeding area of the species. It is observed in migration throughout eastern Arkansas.

STATUS IN ARKANSAS: Endangered as a breeding species; only a dozen pairs in one locality known to breed today.

HABITAT REQUIREMENTS: In Arkansas, it occurs in a grove of wet woods composed of hawthorn species on the edge of native prairie.

RELATIONSHIP TO STUDY AREA: The Willow Flycatcher is observed during migration in woodlands throughout the Study Area. Identification is seldom confirmed since singing is required, but the species has been confirmed within one mile of Bayou Bartholomew.

u. Bewick's Wren, *Thryomanes bewickii*.

RANGE AND STATUS OVERALL: Bewick's Wren breeds from the Mississippi Valley and from central Pennsylvania to northern Illinois and south through the Gulf Coast States. It winters throughout most of its range and its status is declining in the eastern half of the United States.

RANGE IN ARKANSAS: Scattered records throughout Arkansas, but concentrated in the northwest.

STATUS IN ARKANSAS: Declining.

HABITAT REQUIREMENTS: It prefers forest edges, abandoned man-made structures and urban areas.

RELATIONSHIP TO STUDY AREA: This bird has been observed throughout the Study Area, including in the forest communities along Bayou Bartholomew. There are two recent breeding records in the Study Area.

v. Bachman's Sparrow, *Aimophila aestivalis*.

RANGE AND OVERALL STATUS: Bachman's Sparrow breeds from Maryland to southeastern Iowa and south to the Gulf Coast states. It winters north to North Carolina. Its status is undetermined.

RANGE IN ARKANSAS: Scattered localities restricted to central Arkansas.

STATUS IN ARKANSAS: Threatened as a breeding bird.

HABITAT REQUIREMENTS: Bachman's Sparrow usually nests in open pine woods or in old fields having scattered small pines or cedars. It requires fine grass for nest construction. Small colonies will develop in overgrown clearcut areas.

RELATIONSHIP TO STUDY AREA: Bachman's Sparrow is rare in fallow clear-cut areas to the west of the Study Area. It occurs within Study Area in successional fields.

5. Mammals.

Three large mammals have been extirpated from the Study Area. They are the cougar (*Felis concolor*), the black bear (*Euarctos americanus*) and the red wolf (*Canis rufus*). Cougars are presently found mainly in remote regions centered near the Saline and Ouachita River bottomlands in southeastern Arkansas, the White River National Wildlife Refuge, the western Ozark Mountains and the Ouachita Mountains. The red wolf is mostly limited at present to the coastal prairies of southwestern Louisiana (Lowery, 1974).

## E. THREATENED RESOURCES UNDER FUTURE CONDITIONS AND MEASURES REQUIRED FOR PROTECTION (SEE ALSO SECTION VIII).

In general, most of the discussed endangered species depend upon maintenance of poorly drained bottomland hardwoods. Continued drainage and clearing of such areas could eliminate presently existing endangered species and endanger presently threatened or vulnerable species. Local, State or Federal acquisition of bottomlands may be the best measures for protection, as well as modification of agricultural practices (strip cropping, maintenance of buffer areas) to insure less siltation of bayous and wetlands. As long as draining of bottomlands is economically feasible, continuation of this practice will continue to the detriment of many plants and animals.

## F. BIOLOGICAL POTENTIALS IN THE URBAN ENVIRONMENT.

The Pine Bluff urban area, due to its disturbed state, is generally incapable of supporting significant numbers of terrestrial and aquatic fauna. Human activities and land use changes inhibit many forms of wildlife. Extensive cleared areas and the lack of impounded lakes and ponds limit habitat to relatively few urban-tolerant organisms.

1. Urban Terrestrial Potentials.

The Pine Bluff Urban Area offers only limited potentials to most Study Area wildlife forms. Mammals which inhabit the urban area include cottontail rabbits, grey and fox squirrels, oppossums and a limited number of raccoons. Carrying capacities for squirrels are limited by enemies such as domestic cats and the automobile and by relatively low levels of mast production. Cottontail rabbits will be common in the urban area as long as undeveloped grass and brush fields are allowed to remain in their present state. Raccoons, like rabbits, are most common at the outer fringes of the urban area. Birds in the urban area include one sport species, as well as those forms tolerant of disturbed conditions. Bobwhite are found in scattered pine stands in the western fringes of the urban area. Their numbers will be sustained as long as these tracts remain undeveloped. Many passerines are common and are generally tolerant of disturbed urban conditions; their numbers should remain relatively constant regardless of additional urban land use changes. There is little or no potential for aquatic-oriented birds such as herons, stilts and ducks.

2. Urban Aquatic Potentials.

As discussed in Section IV.B., canals and bayous draining the urban area are polluted and provide habitat for only the most tolerant organisms. Because of the physical nature of Outlet and Interceptor canals, these canals, if returned to clean water, would support a more diversified benthic community, but would not support an appreciable fishery.

Natural Study Area watercourses which border the urban area, such as Bayou Bartholomew and Caney Bayou, support a diversified benthic community, fishery and avian and mammalian habitats. Potentials can best be met by preservation and/or restoration of greenbelt areas and abatement of pollution, namely sediment and nutrients. Benthic invertebrate diversity would be especially enhanced by pollution abatement. Fisheries potentials would also be increased with this practice, as well as with the control of floating aquatic vegetation, maintenance of greenbelt areas and non-removal of snags and submerged logs.

No significant lakes and ponds exist in the Pine Bluff urban area. Lakes and ponds at the fringes of the urban area, such as Taylor Lake, Kisatchie Lake and Byrd Lake probably offer the greatest diversification of potentials because of limited development in their watersheds. All three lakes are capable of providing a managed fishery and habitats for birds and mammals. Ownership and limited access presently enhance wildlife potentials. Other Study Area urban fringe lakes, such as those in Oakland Park, are capable of greater fisheries potential through management and control of incoming contaminants, but have only limited wildlife potential due to urban development around them. Potentials for heavily used impoundments such as Lake Pine Bluff and Lake Langhofer are probably close to being met biologically. Domestic sewage limits biological diversity to a degree in both impoundments.

G. COMMON NUISANCE ORGANISMS.

The Pine Bluff Study Area has a number of existing insect, bird and mammal pests that are either a health threat or a threat to the local economy. These

organisms are listed in Table VI-5. In general, pests in agricultural areas represent economic hazards and require expensive methods for their control. Biocides used to control these pests often upset the ecology of natural predatory species or present health hazards to the human community which either ingests contaminated foods or comes into direct contact with spraying. Urban area pests also present health hazards. Adult mosquitoes which hatch from stagnant ponds are capable of spreading diseases such as encephalitis and are occasionally a severe nuisance to area residents. Ticks are capable of spreading Rocky Mountain spotted fever. The brown recluse spider is capable of temporarily incapacitating a human victim. Termites require expensive treatment for their prevention and/or removal. Flies, cockroaches and rats are nuisances in urban areas and are capable of spreading diseases among humans.

## G. RELATIONSHIPS BETWEEN BIOLOGICAL RESOURCES AND THE STUDY AREA ENVIRONMENT.

Changing land use patterns and point source and non-point source pollutants have the greatest effects upon Study Area biological resources. The most deleterious effects upon biological resources in turn affect recreational and esthetic benefits. General effects of land use upon biological resources are discussed in terms of land usage: agriculture, silviculture, urbanization, navigation and flood control, and esthetic and recreational areas. Important biological interactions with other environmental factors are also discussed.

### 1. Agriculture.

Monocultural crop activity is important for mass production and maximum economic benefit, but it invites a host of insect, avian and mammalian pests that respond in population explosions to decreased biological control of such unstable conditions. Biocides must then be applied for control of these pests. Some of the pesticides then bioconcentrate in non-target organisms and plants (Section IV.C). In the Study Area, most of the lands best suited for agriculture are also valuable in terms of wildlife habitat and recreation. This incompatibility can be expressed in economic terms; croplands supply jobs to the area's work force; decreased and degraded terrestrial and aquatic habitats mean less money spent locally for hunting, fishing and recreation gear.

### 2. Silviculture.

Like agriculture, silvicultural practices discourage biological diversity through habitat change. Unlike agriculture, limitations to wildlife and recreational use are not as severe, notably in managed areas. Lesser amounts of toxic biocides are used, lessening stress on non-target individuals. Economic benefits of managed pine forests versus recreational/esthetic benefits are also more compatible in silviculture.

### 3. Urbanization.

Because urbanization is disruptive to native vegetation and wildlife habitat, terrestrial biological resources in such areas decrease dramatically. Aquatic resources change in composition and diversity due to changed hydrologic conditions and degraded water quality. The incompatibility of urbanization

TABLE VI-6
Common Study Area Pests by Land Use

LAND USE

| BEEF CATTLE | COTTON | SOYBEANS | RICE | FORESTRY | VEGETABLES | URBAN (GENERAL) |
|---|---|---|---|---|---|---|
| Cattle grub | Bollweevil | Cutworms | Grape colaspis | Pales weevils | Cutworm | Blackbirds* |
| Horn fly lice | Bollworm | Grape colaspis | Rice water weevil | Southern pine beetles | Wireworm | English sparrows |
| Ticks | Cutworms | White grubs | Stinkbug | Pine tip moth | Flea beetle | Mosquitoes |
| Screwworms | Thrips | Stinkbugs | Grasshopper | Pine sawfly | Hornworm | Cockroaches |
| | Plant bugs | Bollworm | Chinch | Spider mite | Fruitworm | Ticks |
| | Loopers | Loopers | Fall armyworm | Tent caterpillar | Stinkbug | Termites |
| | Spider mites | Three cornered leaf hoppers | | Fall and pine webworms | Aphids | Flies |
| | | Alfalfa hoppers | | Oak leaf miners | Blister beetle | Rats |
| | | | | Two-lined chestnut borers | Mites | Brown recluse spiders |
| | | | | Hickory bark beetles | Earworm | |
| | | | | Pine engraver beetles | Leafhopper | |
| | | | | Turpentine beetles | Looper | |

* Blackbird roosts comprised of red-winged blackbirds, grackles and starlings.

SOURCE: Cooperative Extention Service (1973).

and biological resources can only be alleviated by preservation and enhancement of open green space and greenbelts and by control of point source and non-point source pollutants.

4. Navigation and Flood Control.

In the Study Area, navigation and flood control have different effects upon biological resources and recreation/esthetics. Straightening and stream channelization in Bayou Bartholomew west of Arkansas Highway 15 has drastically altered aquatic productivity in affected areas (Section VI.B). Recreational and esthetic use of the areas is secondary to flood control in those areas. Navigation and flood control projects, such as the McClellan-Kerr Navigation Project, have less apparent incompatibilities with biological resources and recreation. Stabilization of the Arkansas River has enhanced biota such as the Mississippi kite and the river birch communities and has had beneficial effects on the fishery due to reduction of turbidities.

5. Recreational and Esthetic Areas (Environmental Quality).

Biological resources are affected differently by various types of recreational development. An area such as a golf course may attract an occasional deer or rabbit, but by itself cannot support wildlife; a relatively undeveloped greenbelt area would maintain existing flora and fauna and provide different esthetic and recreational values. Water quality degradation from urban and agricultural activities and reduction of forest lands will have the greatest effects on Study Area bayous and lakes; contact sports and fisheries use are degraded due to sediment, nutrient and litter pollution. Figure VI-6 summarizes the various interactions of biological resources and depicts the first and advanced order effects.

6. Interactions with Other Study Area Elements.

Throughout Section VI, various interactions between biota and other Study Area features were discussed. The following will highlight some key interactions that affect, maintain or detract from biological resources.

a. Interactions with Hydrologic Elements.

(1) Flooding.

Bottomland fauna and flora are well-adapted to periodic inundations. In fact, the high productivities of bottomlands depend heavily upon seasonal fluctuations of water. Although area mammals may flee from flooded areas or even perish in them, their numbers are sustained and enhanced by the ultimate benefits of flooding: i.e., nutrients which are taken up by vascular plants, bacteria and algae and passed on to higher trophic levels; seeds which are distributed by floodwaters sprout after waters have receded and provide food and cover for higher life forms. Floodwaters increase habitat and food supply for fishes, herpetofauna and aquatic-oriented birds.

(2) Ground and Surface Water Quantity and Quality.

In the upper reaches of Caney Bayou and Bayou Bartholomew, ground water recharge enables these streams to flow permanently, even in late summer.

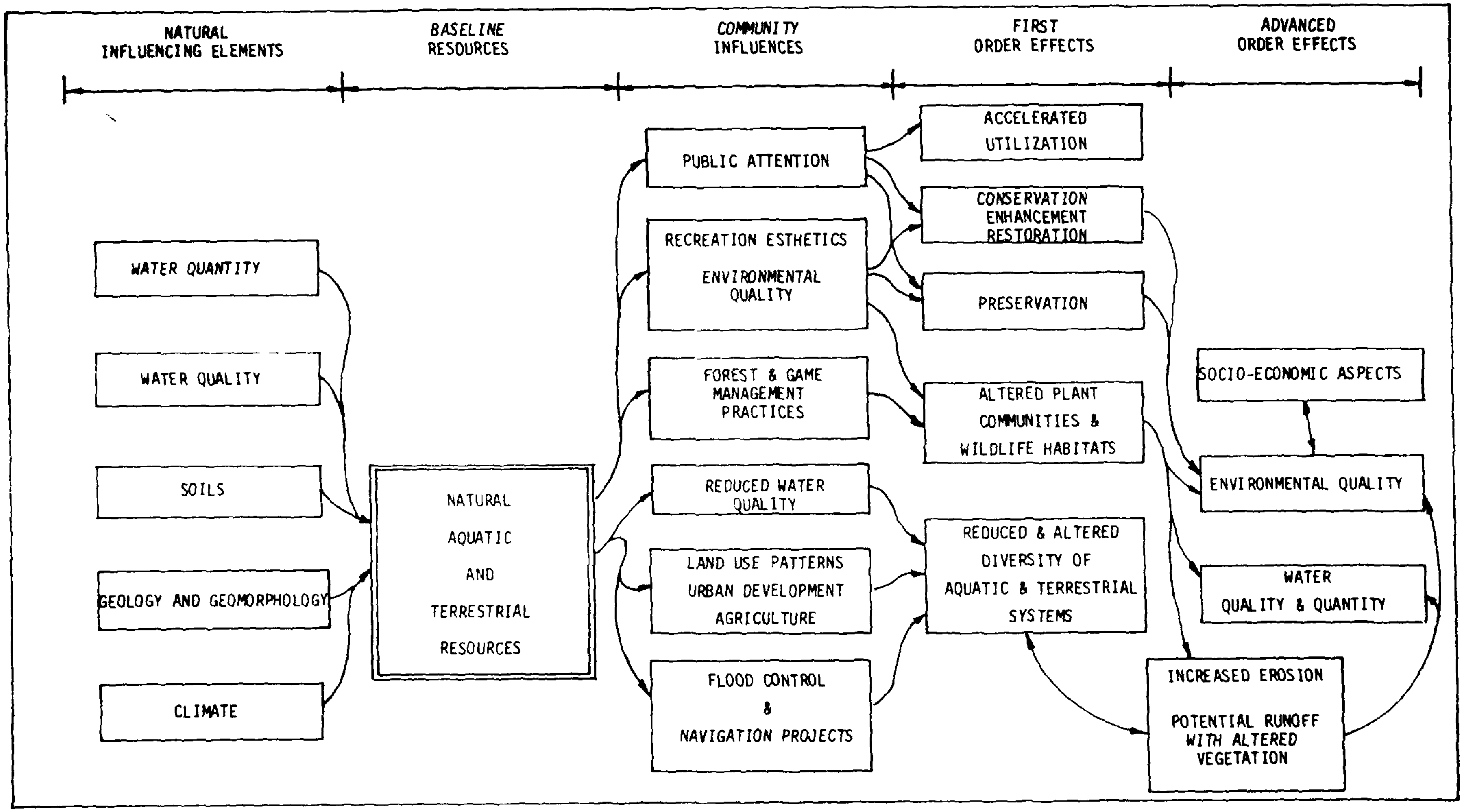



FIGURE VI-6: INTERRELATIONSHIPS OF BIOLOGICAL RESOURCES OF THE PINE BLUFF STUDY AREA

This is of great benefit to aquatic and aquatic-dependent biota in that their habitat is maintained over a greater reach. Effects of ground water recharge in downstream areas are less obvious. Quality of Quaternary aquifer recharge water apparantly does not limit Study Area biota, as does surface water in urban stormwater canals and their confluence areas with Bayou Bartholomew and Caney Bayou.

(3) Climate.

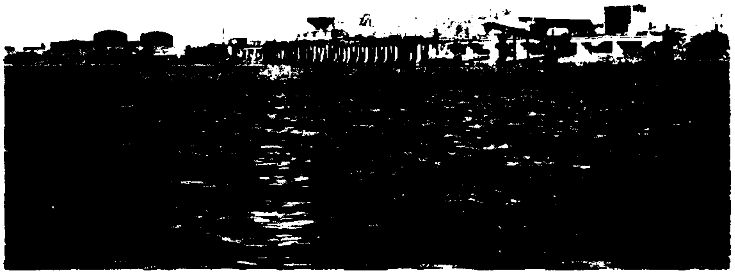
Meteorological phenomena such as rainfall, temperature, wind patterns and storms all help shape the Study Area biotope. Animals such as the nine-banded armadillo have been extending their range northward into Arkansas, probably because of favorable climatic conditions.

b. Interactions with Geologic and Pedologic Elements.

Topography of the Study Area, in conjunction with drainage basins and soil types, is an important determining factor for both plant and animal distributions. Vegetation in the well-drained uplands supports animal populations dissimilar to those found in bottomland forests. Exceptions do occur, as in Pinebergen where natural ridges intersect low-lying areas and support vegetation more similar to uplands than the nearby bottomlands. Soil types in the Study Area are closely allied to past fluviatile occurrences, and, as such determine animal distribution and abundance. Soils in the western portion of the Study Area being more porous, acidic and infertile than the eastern Alluvial soils, do not support the same vegetetion and wildlife as do alluvial soils.

c. Interactions with Biotic Elements.

Throughout Section VI, species occurrences were discussed in terms of relation to other fauna and flora. Removal or reduction of specific biotic elements can upset the ecology of the entire biotope; an example is the removal of bottomland hardwoods for agricultural croplands. The animals inhabiting the bottomlands either flee, adapt or perish and are replaced by organisms tolerant of monocultural conditions.



# ENVIRONMENTAL INTERACTIONS

# VII

# VII
# ENVIRONMENTAL INTERACTIONS

## A. REGIONAL AND NATIONAL SIGNIFICANCE OF VARIOUS STUDY AREA ELEMENTS.

### 1. Arkansas River and Lake Langhofer.

As discussed in Section III, the Arkansas River is primarily responsible for the present location of Pine Bluff. Although the river was utilized for goods shipments for years, navigational hazards in the form of sand bars were seasonally restrictive. Construction of the McLellan-Kerr Navigation System opened the river to year-round shipping and greatly reduced flooding hazards. Construction of the Boyd Point Cutoff levee and a new river channel opened up the first slackwater harbor (Lake Langhofer) on the Arkansas River. Increasing usage of both the port and the river are important factors in the future industrialization and growth of Pine Bluff.

### 2. Pine Bluff Arsenal.

The Federally-owned 15,000-acre U.S. Army Arsenal at Pine Bluff is one of the area's largest industries. Its manufacturing facilities for white phosphorus are the only ones maintained in the entire United States by the U.S. Department of Defense. It also manufactures other munitions vital to this country's national defense.

### 3. National Center for Toxicological Research.

Important cancer research is conducted at this U.S. Department of Health, Education, and Welfare facility, located on former Arsenal land.

### 4. Biological Elements.

#### a. Endangered Species.

All of the endangered species in Section VI.D. are either of regional or national significance. The American alligator, bald eagle, red-cockaded woodpecker and the cougar, all on the Federal Endangered Species List (U.S. Department of the Interior, 1974) either occur in or could be expected to occur in the Study Area. The remainder of species discussed in Section VI.D. have been placed in regional endangered, rare, threatened, vulnerable or undetermined categories for Arkansas by various investigators (Arkansas Department of Planning, 1974).

#### b. Bottomland Hardwood Forests.

In the Study Area, as well as throughout the southern and southeastern United States, bottomland forests are being steadily depleted for other land uses such as agriculture. Continued loss of these forests will further endanger many plants and animals. As discussed in Section VI.D., most of the Study Area's endangered biota flourishes only in poorly-drained forests and swamps. Destruction of those areas will also result in the decline of the logging industry and loss of hardwood lumber products.

5. Esthetic Resources.

Byrd Lake (Figure VIII-2) has significant regional value in that it is an example of a channel scar-type of lake. It is the only lake of this kind found in Arkansas (Arkansas Department of Planning, 1974). Although logging occurred in the past, the lake area is an example of a relatively natural bottomland hardwood forest. Additional discussion of Byrd Lake may be noted in Section VIII.B.2.

6. Cultural Resources.

a. Archeological.

There are 22 known archeological sites within the Study Area (Section IX.B.). Possible presence of Paleo-Indian sites, the earliest recognized cultural manifestation in the New World, merits both regional and National significance.

b. Historical.

Pine Bluff has four structures currently listed on the National Register of Historic Places; the Hudson-Grace-Borreson Home, Du Bocage, Trinity Episcopal Church and Dollarway Road.

B. EFFECTS OF FUTURE LAND USE AND WATER QUALITY ON EXISTING INTERACTIONS.

1. Present Land Use and Water Quality.

The intimate relationship of land use to water quality has been discussed in Section IV and graphically illustrated in Figures III-2 and IV-1. Stormwater contributions from urban areas have a more significant effect upon water quality than non-urban areas in terms of nutrients and organic loading, and, in the affected drainage systems, severely limits biological diversity and recreational/esthetic uses. Agricultural pollutants such as sediment and adsorbed nutrients and pesticides seriously limit biological and esthetic resources in local meanders and wetland areas more than in local stream systems.

2. Future Land Use and Water Quality Effects Upon Existing Interactions.

Future land use changes are expected to have the greatest effects upon Quaternary Terrace terrestrial ecosystems and upon most Study Area aquatic ecosystems. Loss of forest lands to new urban areas northwest, southwest and south of Pine Bluff will reduce game-carrying capacities significantly in those areas, plus expose large acreages of soil to erosive conditions. Aquatic ecosystems below those developments (such as below Station 3) will continue to deteriorate; fisheries losses in those areas will reduce recreational uses.

Improvement of the sewerage collection system in the Outlet Canal drainage area should improve its water quality. Although pollution abatement is not expected to enhance usage of Outlet Canal for fisheries or recreation, the canal's influence upon Bayou Bartholomew water quality should lessen. However, water quality at Station 5 will continue to deteriorate due to contributions from two proposed 70-acre oxidation ponds 7 miles upstream. Fisheries and recreation in that area probably would offer much more limited potential than at present.

Water quality at Station 7 should improve due to aeration-pump implementation on the upstream Caney Ponds; however, input of the Whitehall oxidation ponds will offset this potential change. Fisheries and recreational usage of Caney Bayou should not change significantly.

Agricultural cropland influences upon area aquatic ecosystems will not change significantly in the future because expansion into wetland areas will be limited. Construction of the Bartholomew Expressway through the Bayou Bartholomew floodplain could severely limit aquatic habitats through sedimentation and hamper recreational and esthetic use of the projected city-owned Greenbelt due to noise levels during construction, automobile exhaust and the presence of the Expressway.

Changes in air quality due to industrialization should generally have little impact upon existing interactions, except in areas immediately south of the White Bluff coal-fired generating plant. Sensitive vegetation could be adversely affected by $SO_x$ and $NO_x$ emissions, and plant uptake of heavy metals could adversely affect the ecology of foraging animals such as rabbit, squirrel, deer and bobwhite. Additionally, localized air inversions could occasionally pose a health hazard to humans and wildlife.

In summary, future land use changes will have significant localized effects upon terrestrial and aquatic ecosystems and recreational/esthetic usage. Overall, however, existing interactions are not expected to be significantly affected by these changes.

## C. SUMMARY OF ENVIRONMENTAL POTENTIALS IN THE STUDY AREA.

As discussed in Section VI.C.3., terrestrial habitats in the Study Area are capable of supporting large game and non-game animal populations. Animals such as deer, raccoons, swamp rabbits and songbirds would be common in bottomland hardwood areas.

Increase of aquatic habitats through pollution abatement and greenbelt enhancement could significantly enhance the Study Area's species diversity and fisheries. Pollution abatement could also make Study Area lakes and streams suitable for contact recreation and industrial use.

## D. STUDY AREA ELEMENTS THAT COULD LIMIT FUTURE DEVELOPMENT OF FULL ENVIRONMENTAL POTENTIALS.

### 1. Terrestrial Ecosystems.

With agriculture retaining its economic importance to Pine Bluff, the likelihood of increased bottomland hardwood forest habitats and associated game is severely limited in the eastern and southeastern portions of the Study Area. Agricultural pesticide usage will continue to place undetermined limitations upon predatory bird and mammal populations; based upon limited information presented in Section IV.C.2., pesticide uptake (notably DDT) appears to be problematic in or near areas heavily utilized for agriculture. Upland and bottomland terrestrial habitats will be reduced in areas projected for urban growth and transportation corridor placement. This will be especially

pronounced in areas immediately south, southwest and northwest of the Pine Bluff urban area. Silvicultural practices in upland areas will limit game-carrying capacities in those areas.

2. Aquatic Ecosystems.

Increased urbanization and industrialization will demand additional ground water; much of this ground water will ultimately reach local streams and bayous. The degree of treatment will, therefore, determine the effects upon aquatic ecosystems.

Continuing agricultural practices such as row crop cultivation and wetland drainage will continue to limit aquatic resource potentials in wetland areas east of Pine Bluff.

Irrigation withdrawals from the Quaternary aquifer could reduce flows from perennial to intermittent in Bayou Bartholomew headwaters and, subsequently, adversely affect aquatic potentials throughout large segments of the bayou.

Continued urban encroachment into greenbelt areas will reduce aquatic productivities and fisheries potentials in affected areas.

Septic tank overflows in impermeable soils will continue to degrade water quality and aquatic diversity until alternative collection and treatment facilities are constructed.

In summary, environmental potentials will continue to be limited by various land usages. Some land use practices such as cropland cultivation will continue to contribute pollutants to waterways; implementation of environmentally compatible, but less profitable, managament techniques is unlikely at present. Aquatic communities will be enhanced by reductions of sediment from construction activities if retention structures and revegetation practices are used for control of such pollutants. Urban land activity will continue to contribute oxygen-demanding stormwater to area streams. Improved and expanded sewerage collection facilities will improve water quality and enhance aquatic ecosystems; however, increased amounts of urban wastewater may offset these improvements.

## E. ENVIRONMENTAL ELEMENTS THAT COULD LIMIT FUTURE WATER RESOURCES DEVELOPMENTS.

Future water resources developments include the areas of: flood control, water supply, wastewater management, water quality, water-based recreation, navigation and environmental quality.

1. Flood Control.

Although flood protection has been substantially increased over the past few years, damaging floods on Bayou Bartholomew in the vicinity of Pine Bluff occur two to three times a year and cause significant damages every three to five years. The increased urban development of recent years in and adjacent to the Bayou Bartholomew floodplain has resulted in a condition whereby a major flood would be devastating. Moreover, there are numerous locations within the

Study Area vulnerable to local flooding due to poorly developed runoff patterns (U.S. Army Corps of Engineers, 1974a; see Section II).

Detailed solutions to flood problems have not been delineated and will require a careful analysis of the condition and effectiveness of existing flood control measures and stormwater collection facilities. Possible alternative solutions, however, might include reservoirs, retention basins, channel improvements, levees, floodwalls, pumping plants, floodplain and land use management, flood proofing, or flood insurance programs.

The environmental constraints to these and other possible alternatives center on the conflict between flood control and the maintenance of environmental quality through the preservation of natural or semi-natural conditions. Although constraints to the engineering of specific projects imposed by soil and geological properties, climate, and area hydrology are viewed as minimal, effects of drainage improvements could upset the recharge capacities of the Quaternary aquifer, thus seasonally limiting uptake of water and flows in area streams. Reservoirs and retention basins would directly remove bottomland areas from high biological productivity; release of deoxygenated waters from such structures could be restrictive to downstream aquatic fauna. In addition to esthetic losses, floodplain reservoirs would not greatly enhance area recreation, as both lakes Langhofer and Pine Bluff are sites for such activities as fishing and other water-based recreation (Section VIII).

Bayou Bartholomew and its tributaries in the Study Area are a potentially highly productive aquatic system, but deteriorating and fragile with the degradation of its water quality and with the gradual loss of its floodplain. Classical flood control measures such as straightening, clearing and snagging, deepening or the construction of levees are designed to maintain flood waters in a prescribed channel and to facilitate drainage. As discussed in Chapter VI, sedimentation and reduction of seasonal water fluctuations in the floodplain will seriously reduce the biological diversity of Bayou Bartholomew and its tributaries. In short, the resolution of the conflict between flood control and preservation of aquatic environmental quality will be difficult and as much emphasis as possible should be accorded land use management alternatives: greenbelt and floodplain land use restrictions and control of non-point pollutants emanating from existing floodplain land uses.

2. Water Supply.

Over ninety per cent of current water supply needs are satisfied by ground water resources and as such are limited only by the physicochemical characteristics of the various aquifer systems (Section IV). Future ground water supply needs will be limited by the potential yields of the various aquifer systems, particularly that of the Sparta Sands. Large scale ground water withdrawals of the future may greatly enlarge the existing cone of depression in the Sparta Sand and establish new cones of depression in the Quaternary and Jackson-Cockfield aquifers. This will result in increased pumping costs, continued declining water levels, and lessen the prospects for major growth and development of the Study Area. Future utilization of the currently undeveloped aquifers, notably the Carrizo Sands and Cane River Formation, will be limited by the excessive depths of the former and the high mineral content of the latter.

Future surface water use, as yet unprojected, may be severely limited by the seriously degraded water quality projected for the future. Irrigation and

the watering of livestock by surface water may be prohibited without treatment of pathogens if the proposed criteria for water quality (U.S. Environmental Protection Agency, 1973b) is implemented. Uses of future surface waters for industry or as a raw water source for public supplies may also be limited by extensive costs of treatment. Among the various solutions to the problems of water supply, diversions, reservoirs, and pipelines may be considered, but each would be constrained or limited by the needs of environmental quality. Artificial aquifer recharge, withdrawal management and wastewater reuse may also be considered as alternatives, however, solutions would be constrained more by technology and social attitudes than by environmental elements per se.

3. Wastewater Management.

Measures to be considered as possible solutions to wastewater problems as detailed in Section IV will include the following: advanced biological treatment, physical-chemical treatment, land treatment, and combinations of the above to meet current requirements based upon existing wastewater plans. Solutions to wastewater problems will be aimed at minimizing water quality degradation from waterborne waste and maximum efficient wastewater reuse (U.S. Army Corps of Engineers, 1974a).

All alternative plans are complex and technical, and they will be limited by their own specific engineering requirements. Soils characteristics, geologic formations and water requirements will each play a key role in the analysis of their feasibility. At present, however, conspicuous environmental factors which would limit the development of any wastewater alternatives are not apparent. Public concern for environmental protection and public rejection to the recycling of human wastes represent incompatibilities which may have to be resolved through educational programs.

4. Water Quality.

Some of the numerous methods to be considered in meeting Federal, State, and local water quality criteria are land management, erosion control, low flow augmentation, and retention storage (U.S. Army Corps of Engineers, 1974a). At present, the only environmental elements that could limit the development of one or more of the possible alternatives is the existing water quality and the numbers of both point and non-point discharge sources (see Section IV).

5. Water-based Recreation.

Future water-based recreation needs can be met by a number of alternatives which include among others: development and expansion of existing sites, providing access, floodplain utilization, new parks and greenbelts, land acquisition and subsidy, land use regulation, and new lake development. The most serious environmental limitation to each of these plans will be the maintenance of high water quality. For the lake systems, the water quality of the future will probably be sufficient for secondary contact recreation and, in some instances, primary contact. Major pollution control efforts, however, will be necessary before Bayou Bartholomew, Caney Bayou, or portions of Lake Pine Bluff will be safe for primary contact sports (see Section IV). Other limitations to future recreation will be the control of conflicting land use patterns such as those now at Boyd Point and at the Ste. Marie Recreational Area (Section III). Briefly restated, these conflicts are water sports/industrial usage and parkland/loss of habitat.

6. Navigation.

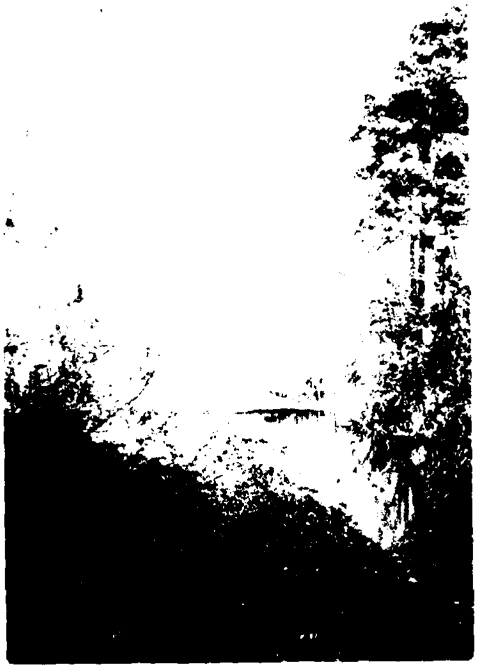
Pine Bluff is the first port on the Arkansas River and it has the only slack-water harbor on the waterway. Because of this, navigation and harbor facilities will be an important part of the city's future. Although future tonnage has not been projected, it is expected to increase. Among the potential solutions to navigation needs are channel and harbor improvements, dredging, navigation aids, dikes, low flow augmentation, increased facility capacity, and new facilities. In addition, local interests have indicated a need for enlarging harbor facilities and fleeting areas.

Construction and engineering limitations imposed by environmental factors will be minimal and the major environmental constraints to future navigation and port facility development will be the conflict of specific improvement projects with water quality, biological productivity, and water-based recreation. As with flood control, the conflict will not be easily reconciled. Lake Langhofer, where most of the navigation improvements will occur, has some of the best water quality (Section IV), has high biological diversity (Section VI), and is a target for much of the future recreational facilities (Section III).

7. Environmental Quality.

Throughout the Study Area, numerous lakes, ponds and natural areas (Section VIII) provide habitats for a variety of fish and wildlife species and esthetic areas for many forms of outdoor recreation. In addition, streams such as Bayou Bartholomew and the lower segment of Caney Bayou near Lake Langhofer are considered environmentally significant due to their natural scenic beauty and their value as a fish and wildlife habitat even though fecal bacteria limit contact water sports in these streams. These streams also provide an attractive setting for numerous outdoor activities.

Possible plans for environmental needs of the future include restoration, preservation, and enhancement of existing environmental assets through land use regulation, guidelines for development and construction, and enforcement of existing statutes. Such assets include: scattered archeological sites (Section IX); streamside stands of mature hardwoods in upland areas, bottomland hardwoods serving as habitat and retention basins for natural assimilation of upstream pollutants, remnant prairies and biologically unique areas such as Byrd Lake (Section VI); and existing quality and quantity of Sparta Sand and Alluvial aquifers (Sections II and IV). Implementation of plans for restoration, preservation and enhancement of such features will conflict with the needs for flood control, which may reduce the attractiveness of the bayous, and the needs for urban development and agriculture, which may encroach onto the floodplains and eliminate many of the smaller ponds and natural areas. Also, unabated water quality problems may reduce the environmental quality potential of many areas, especially Caney Bayou and Bayou Bartholomew. Similarly, future navigation projects may seriously impair the environmental quality of Lake Langhofer.



# ESTHETIC RESOURCES AND ENVIRONMENTAL USE AND MANAGEMENT AREAS

# VIII

# VIII
# EXISTING ESTHETIC RESOURCES AND ENVIRONMENTAL USE AND MANAGEMENT AREAS

Jefferson County has a wide variety of recreational, esthetic, and environmental resource areas as a result of its diverse topography and geologic history. It has numerous river escarpments to the east and rolling uplands to the west. This diverse topography and numerous waterways, have created many scenic and environmentally unique areas. The future recreational developments for the Study Area as presented in the Master Park Plan, (Hodges *et al*., 1974) are presented in Section III.

## A. RECREATIONAL RESOURCES.

### 1. Jefferson County.

An inventory of the recreational resources of Jefferson County was compiled by the Pine Bluff Parks and Recreation Department during the summer of 1974. A total of 68 recreation locations were evaluated for available facilities, use, areal extent, administration, accessibility, and other pertinent characteristics. Inventory results for each of the 68 areas are appended (Appendix E).

### 2. Pine Bluff Urban Water Management Study Area.

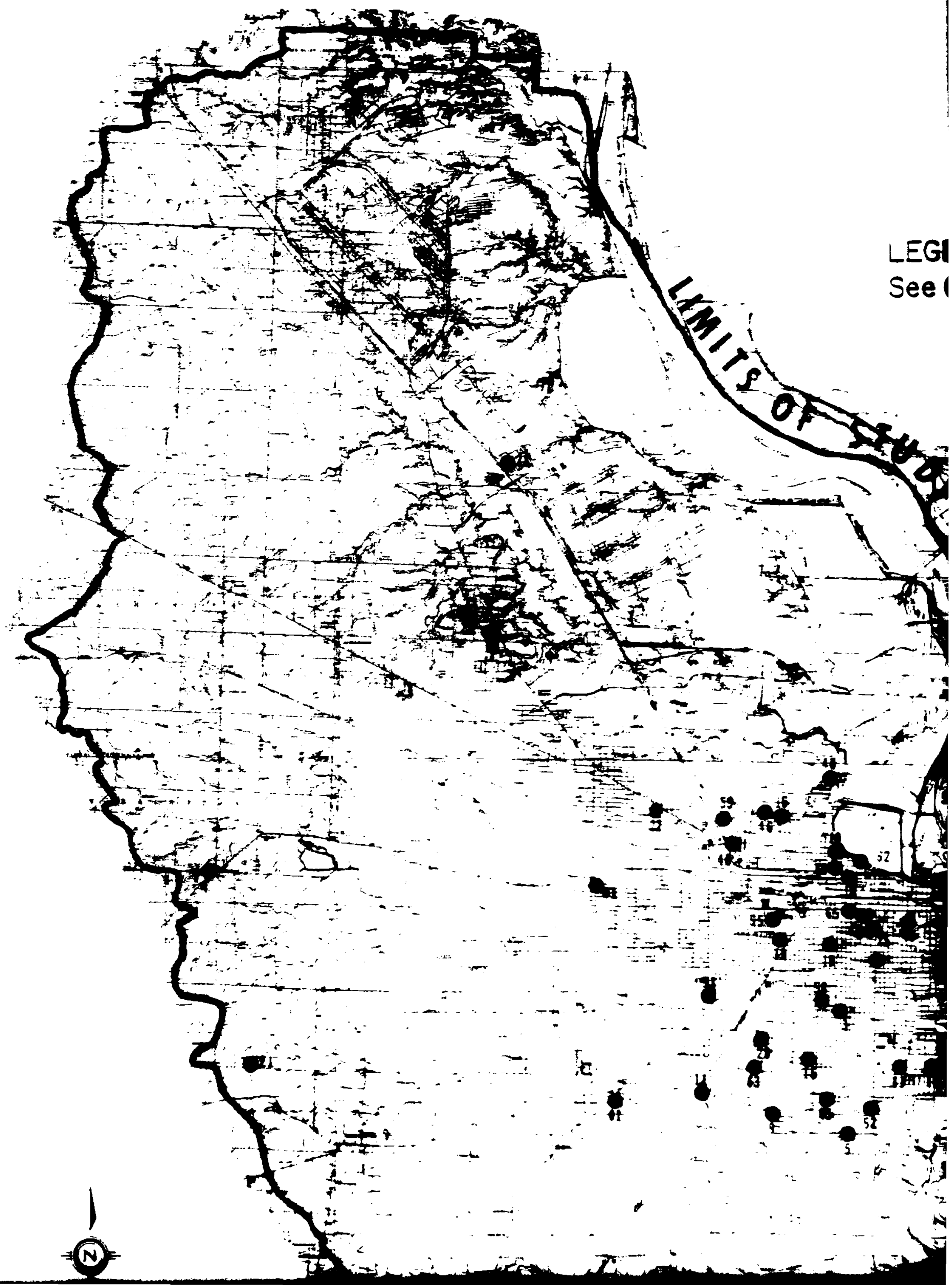
The aforementioned recreational resources inventory (encompassing Jefferson County) consists primarily of recreational areas near the City of Pine Bluff. Those recreational facilities in the Study Area are illustrated on Figure VIII-1 and listed in Table VIII-1. Characteristics of each recreational area are appended; however, the primary recreational resources have been grouped and are discussed below.

#### a. Schools.

The facilities of the Pine Bluff public school system were opened for adult sport participation in 1974. Softball, basketball, soccer (kickball), football and track activities compliment existing playground facilities. Activities are available at no charge to participants.

#### b. Ballfields.

Organized baseball is a popular outdoor pastime in Pine Bluff. Exclusive of the baseball facilities of the public schools, Pine Bluff has eight baseball parks which serve teams from the Little League to organized city teams. In the past, Pine Bluff has been host to the Babe Ruth World Series of Baseball.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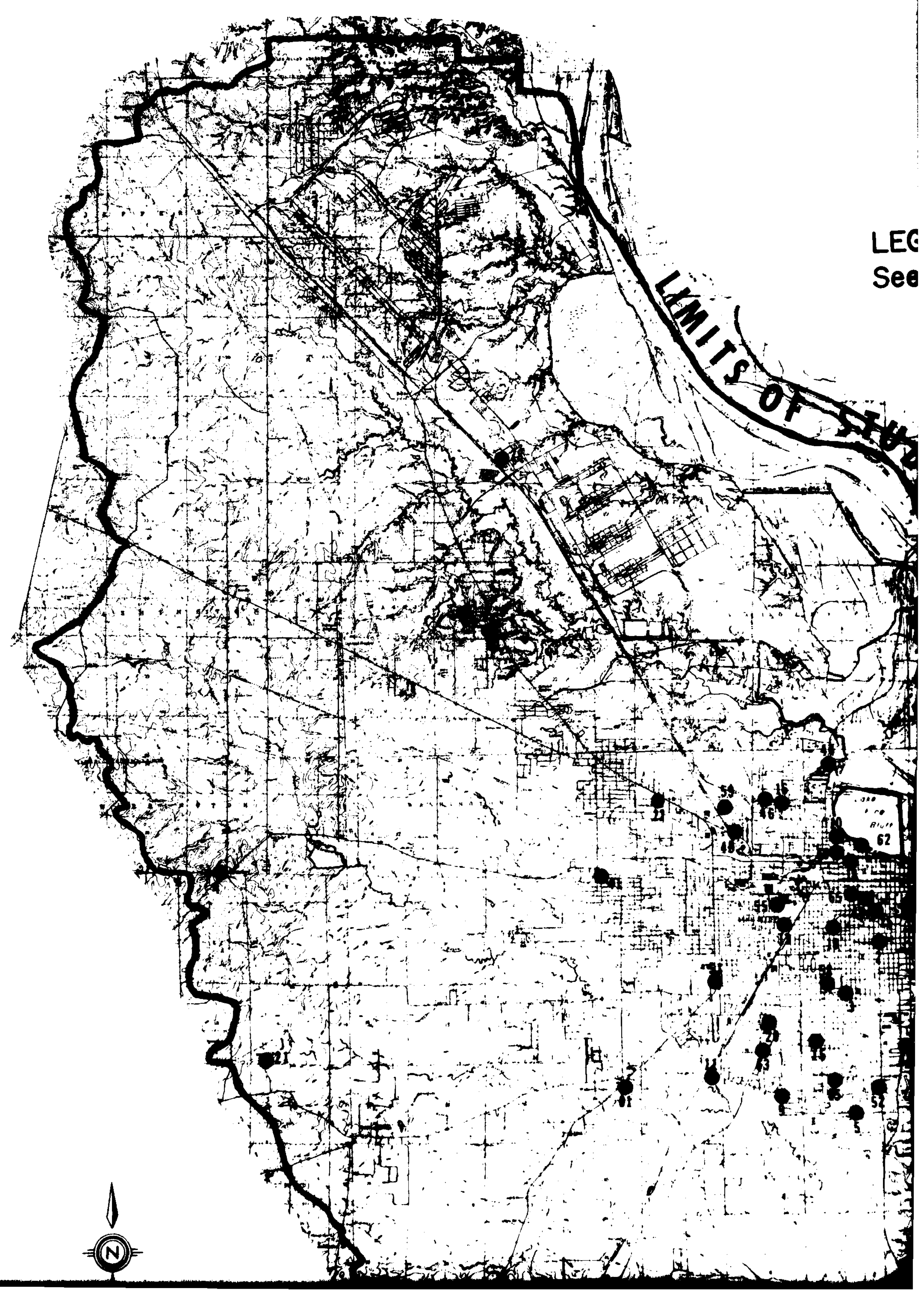
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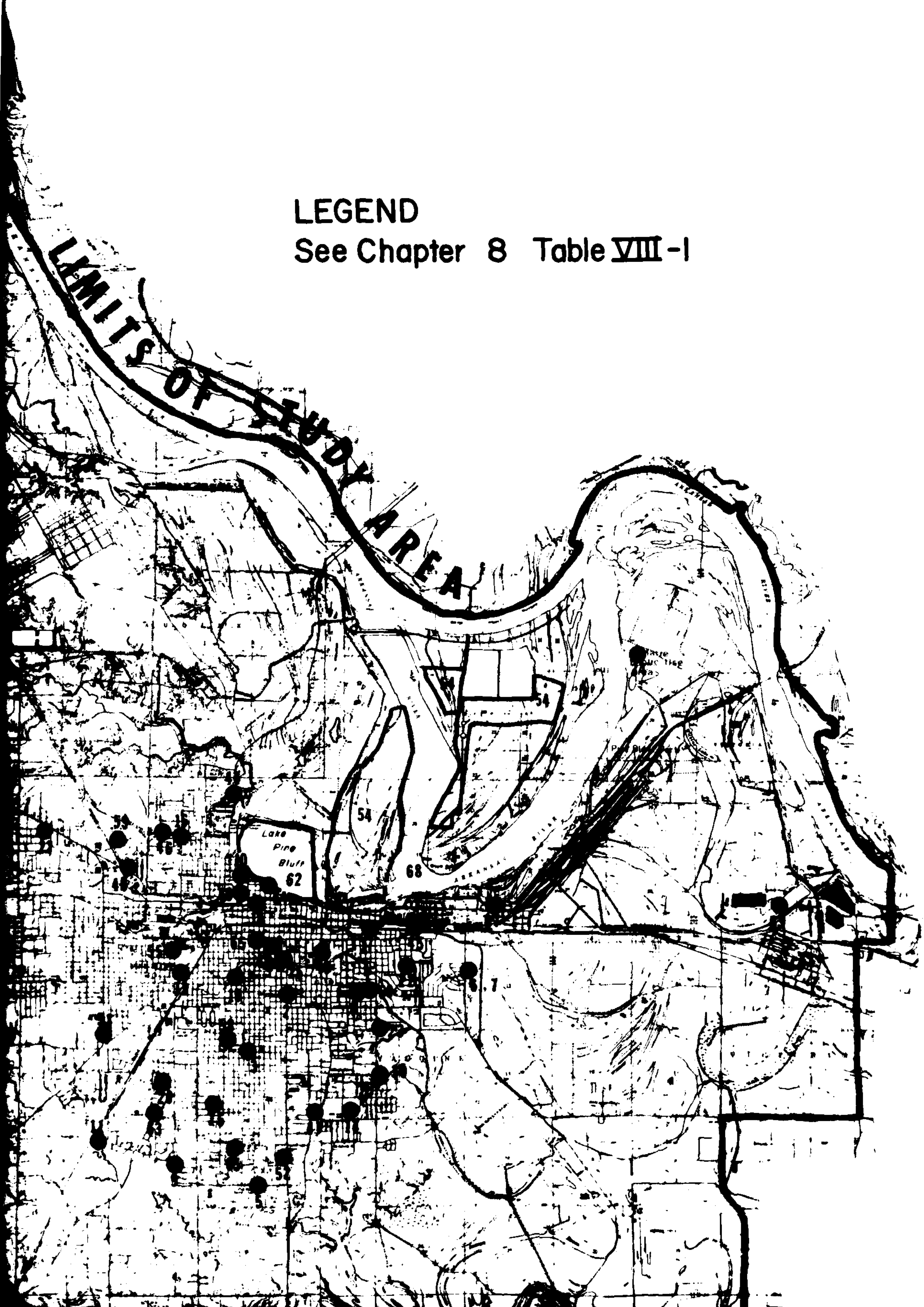

LEGEND
See Chapter 8 Table VIII-1
LIMITS OF STUDY AREA
Lake Pine Bluff
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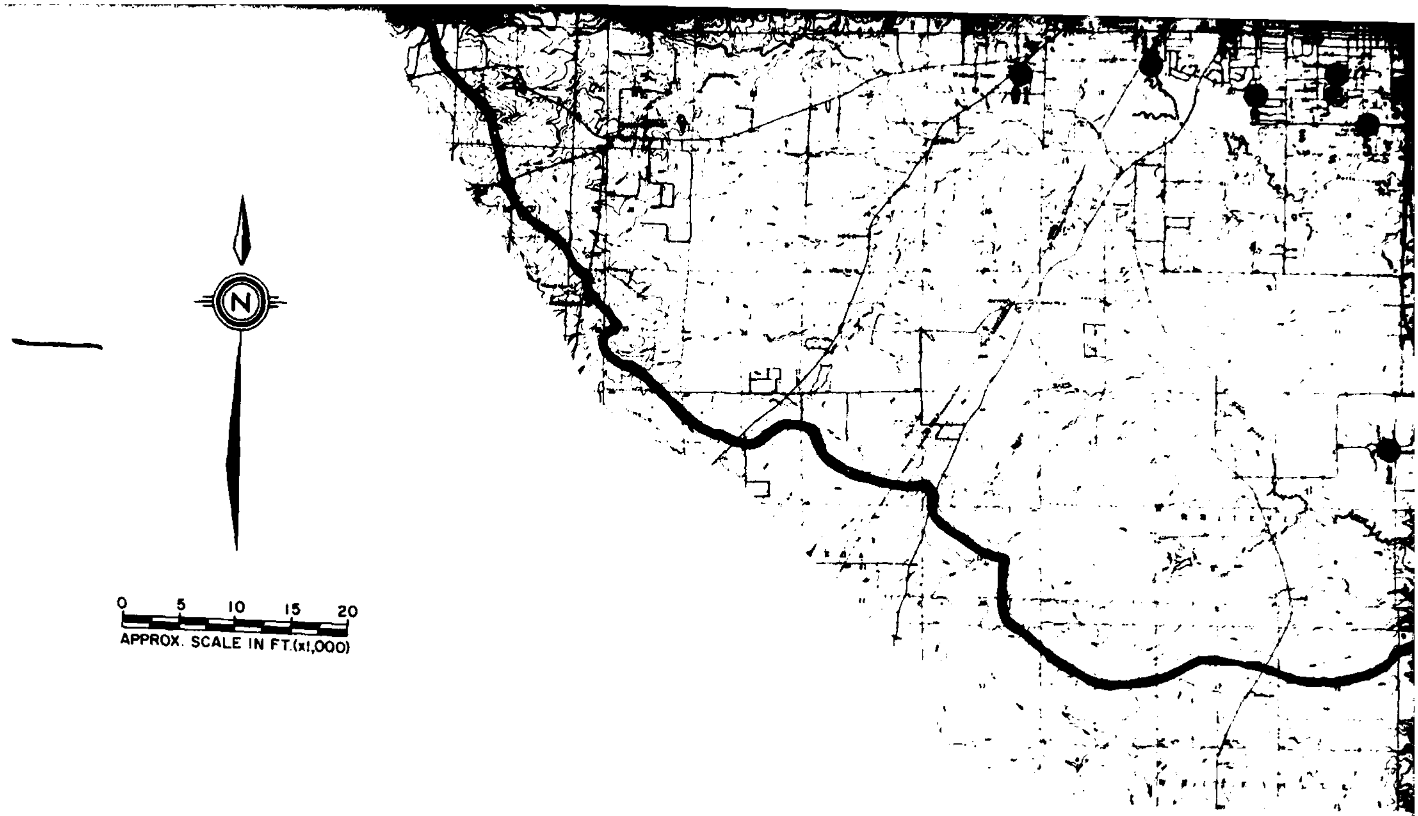
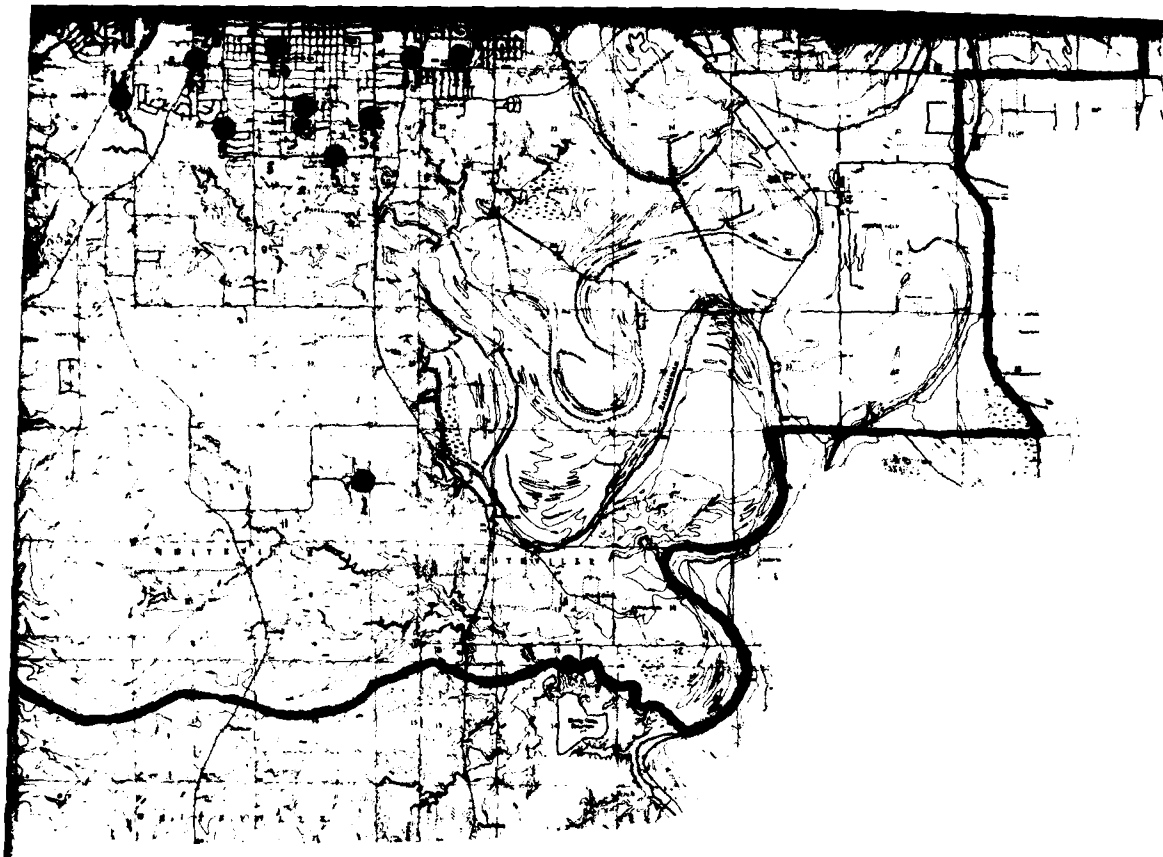
54
68




# RECREATIONAL RESOURCE
# OF THE PINE BLUFF STUDY A



L RESOURCES
JFF STUDY AREA

FIG. VIII-1

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TABLE VIII-1

RECREATIONAL RESOURCES OF THE PINE BLUFF STUDY AREA

| MAP CODE (FIGURE VIII-1) | RECREATION AREA |
|---|---|
| 1 | Rosswood Country Club |
| 2 | Lakeside Elementary School |
| 3 | Gabe Meyer Elementary School |
| 4 | Barnes Memorial School |
| 5 | Pine Bluff Country Club |
| 6 | Belair Junior High School |
| 7 | Belair Elementary School |
| 8 | Indiana Elementary School |
| 9 | Southwood Elementary School |
| 10 | Carver Elementary School |
| 11 | Butram Country Club |
| 12 | Broadmoor Elementary School |
| 13 | Greenville Elementary School |
| 14 | Thirty-Fourth Avenue School |
| 15 | Forrest Park Elementary School |
| 16 | Citizens Boys Club |
| 17 | First Ward Elementary School |
| 18 | Merrill Junior High School |
| 19 | Sam Taylor Elementary School |
| 20 | Oak Park Elementary School |
| 21 | Kiwana's Girl Scout Camp Taloha |
| 22 | Dollarway School District Three Sites |
| 23 | Southeast Junior High School |
| 25 | Pine Bluff Senior High School |
| 28 | Pine Bluff Arsenal Playground |
| 29 | White Hall City Park |
| 30 | White Hall School District Three Sites |
| 34 | Ste. Marie |
| 39 | Twenty-Eighth and Ohio Park |
| 40 | Civic Center Park |
| 41 | Third and Grant Park |
| 44 | University of Arkansas at Pine Bluff |
| 45 | Hutson Park |
| 46 | Townsend Park |
| 47 | American Legion Baseball Park |
| 48 | Western Little League Park |
| 49 | American Little League Park |
| 50 | Taylor Baseball Field |
| 51 | Bush Baseball Park |
| 52 | Eden Park Country Club |
| 53 | Johnson Lake |
| 54 | Regional Park |
| 55 | Ninth and Gum Park |
| 58 | Central Park |
| 59 | Oakland Park |
| 60 | Brumps Bayou Park |
| 61 | National Little League Park |
| 62 | Lake Pine Bluff |
| 63 | Eastern Little League Ballfield |
| 65 | Dial Junior High School |
| 67 | Packing Town |
| 68 | Lake Langhofer |

Source: Pine Bluff Parks and Recreation Department, pers. comm.

c. Camps.

Probably the most noted youth camp in the area is Camp Taloha, a Kiwanas sponsored Girl Scout Camp. A total of 160 acres of land, inclusive of a 22-acre impoundment, enhances such activities as swimming, hiking and camping.

d. Country Clubs.

Three country clubs are active all year round in Pine Bluff. Two offer 18-hole golf courses and all three offer dining and lounge privileges, tennis courts and numerous recreational programs. Membership is selective and fees are charged.

e. Public Parks.

The four public parks in the City of Pine Bluff offer such recreational facilities as swimming pools, picnic grounds, miniature golf, ball fields, amusement rides, and lakes. Oakland Park, the largest in the city, offers a nine-hole municipal golf course.

f. Marinas.

There are two public marinas in the Pine Bluff area. The Ste. Marie facility which contains picnic tables, pavillions and a boat launch area to Lake Langhofer, a 2,000-acre harbor-lake water body. Ste. Marie is very popular for its fisheries resources, water skiing and diversified bird life.

Diagonally, across Lake Langhofer from the Ste. Marie park area, is Danaher's Marina, a public facility which is utilized by boaters and fishermen. The island on which Danaher's Marina is located, Boyd's Point, is a low-lying area noted for its diversified avifauna. The area, due to its proximity to ample water supplies, is a popular resting area for migrating shore birds and other waterfowl. The oxidation ponds which are operated on Boyd's Point by the City of Pine Bluff, offer an excellent sanctuary for game waterfowl such as mallards, pintails, shovelers, and scaup.

g. Lake Pine Bluff (see also Plate VIII-1)

Located adjacent to the downtown area of Pine Bluff, this 500-acre impoundment offers the city and regional populace convenient access to excellent fishing enhanced by the Arkansas Game and Fish Commission's stocking program. Public launching ramps are located at the end of Beech, Poplar, Linden and King streets. Commercial boat dock services are available at the southwest corner of the lake.

h. Wildlife Preserves and Refuges.

The only wildlife preserve in the Study Area is located on the Pine Bluff Arsenal. The preserve is a 10-acre tract. The City of Pine Bluff has an ordinance which restricts shooting within the city limits.

Plate VIII-1 Public boat launch on Lake Pine Bluff

The State of Arkansas Bayou Meto Game Management Area (32,525 acres) is located outside of the Study Area, 15 miles east of Pine Bluff. Here, local rice fields serve to attract large numbers of migratory waterfowl. There are 1,110 acres of water contained in the Bayou Meto Refuge, which was fully acquired by the Arkansas Game and Fish Commission in 1968 (Arkansas Department of Planning, 1973b). In addition, the White River National Wildlife Refuge is located about 60 miles east of Pine Bluff and the Ouachita National Forest, about 70 miles west.

## B. EVALUATION OF ENVIRONMENTAL AND ESTHETIC RESOURCES.

To evaluate environmental (see also Section VI-B.3 and C.3) and esthetic resources in the Study Area, 35 areas (Table VIII-2, Figure VIII-2) were selected after consultation with a Citizens Advisory Committee (CAC). These areas differ considerably from the inventory compiled by the Pine Bluff Parks and Recreation Department (Table VIII-1) because the purposes for these two sets of data were quite different. Table VIII-1 is a listing of existing, developed recreational facilities and Table VIII-2 is a listing of areas which warrant preservation, restoration and/or enhancement. It should also be noted that some of these areas are natural or scenic and are, therefore, not "developed". Five of the 35 areas considered to merit special attention follow.

### 1. Lake Pine Bluff (see also Section VIII.A).

This lake is easily accessible through any of four public boat launching sites. The Arkansas Game and Fish Commission owns and manages this lake.

Lake Pine Bluff is extensively fished for bass, crappie, other sunfishes and catfishes. It is also the habitat of many birds.

The recreational potential of Lake Pine Bluff will be greatly improved by the development of the parks proposed by the Pine Bluff Parks and Recreation Department. The facilities will be a neighborhood park along Brumps Bayou and a large regional park bordering the eastern shoreline of the lake (see Section III). Once developed, these parks will have the effect of establishing a greenbelt area or buffer zone around the edge of the lake and will greatly enhance the recreational and esthetic value of this environmental resource.

The cultivation of vegetation conducive to avifauna would also enhance the recreational and esthetic value of the lake. The lake would be more extensively used by local ornithologists and sportsmen and thereby provide increased educational and recreational opportunities.

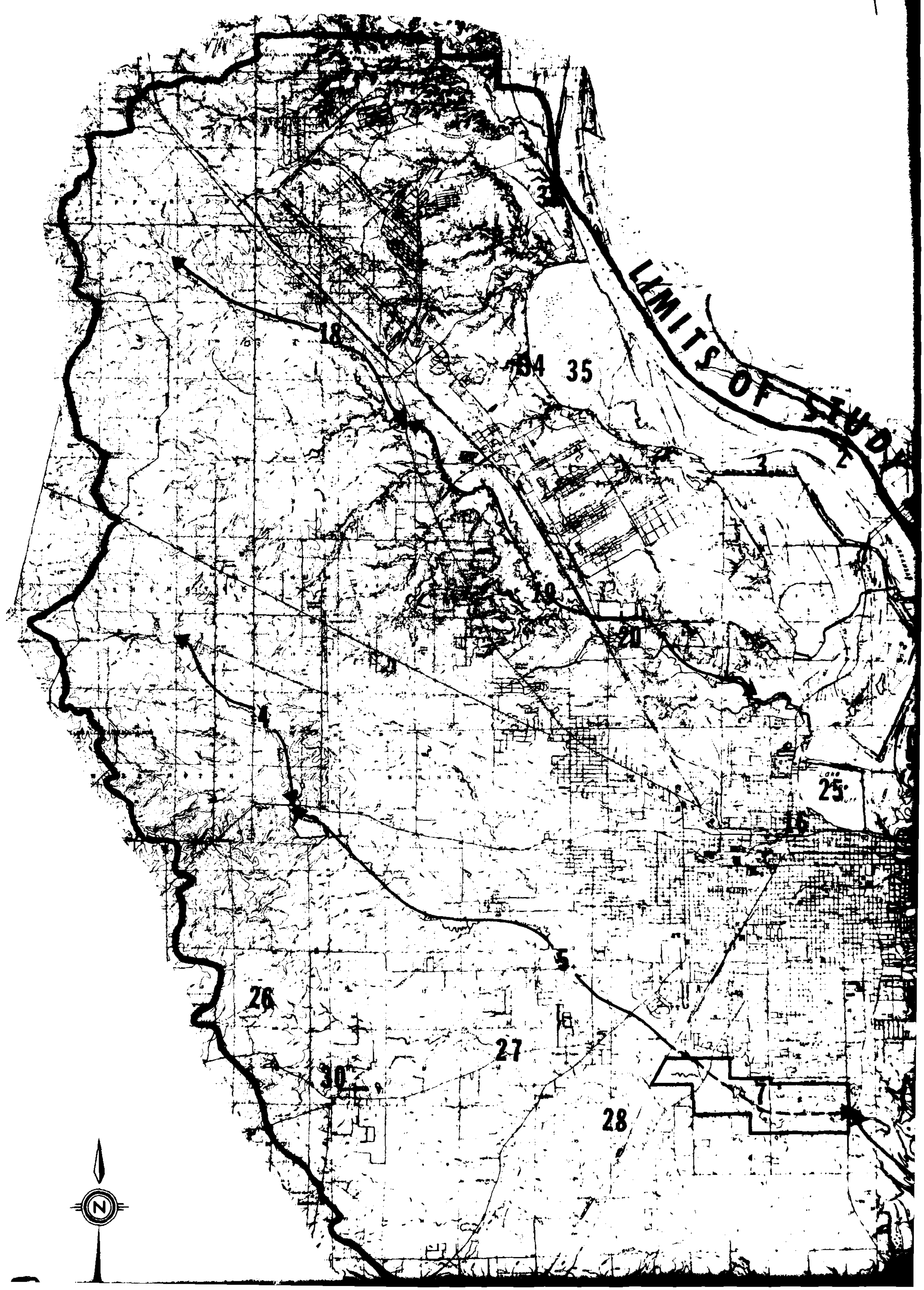
The lake could be esthetically improved by removing some of the dead standing trees, while some should be left for fish habitat. Other esthetic improvements could be made by the establishment of land use regulations that would restrict the types of development permitted along shoreline areas. Such regulations would be primarily concerned with the prevention of land use that would either conflict with or restrict the recreational, esthetic or environmental qualities of the lake. Other means of esthetic enhancement

TABLE VIII-2

ENVIRONMENTAL AND/OR ESTHETIC RESOURCES OF THE PINE BLUFF STUDY AREA WHICH WARRANT RESTORATION, PRESERVATION OR ENHANCEMENT

| MAP CODE (FIGURE VIII-2) | RESOURCE AREA |
|---|---|
| 1 | Alice Brake |
| 2 | Arkansas River |
| 3 | Arkansas River Wetlands |
| | Bayou Bartholomew |
| 4 | above Princeton Pike Road |
| 5 | between Princeton Pike Road and Olive Street |
| 6 | below Olive Street |
| 7 | Bayou Bartholomew Greenbelt |
| 8 | Bayou Imbeau |
| 9 | Blackdog Lake |
| 10 | Boggy Bayou |
| 11 | Boyd Point Beach |
| 12 | Boyd Point Levee Lakes |
| 13 | Boyd Point "Sanctuary" (oxidation ponds) |
| 14 | Boyd Point Wooded Areas |
| 15 | Bream Lake |
| 16 | Brumps Bayou |
| 17 | Byrd Lake |
| | Caney Bayou |
| 18 | above U.S. Highway 65 |
| 19 | below U.S. Highway 65 |
| 20 | Caney Bayou Wetlands |
| 21 | International Paper Company Wildlife Management Area |
| 22 | Island Harbor Marina Road |
| 23 | Johnson Lake |
| 24 | Lake Langhofer |
| 25 | Lake Pine Bluff |
| 26 | Lake Taloha |
| 27 | Nevins Creek |
| 28 | Pidgeon Creek |
| 29 | Ste. Marie Recreational Area |
| 30 | Sulphur Springs Area |
| 31 | Taylor Lake |
| 32 | Tripletts Bluff |
| 33 | Wilkins Lake |
| 34 | Yellow Bluff |
| 35 | Yellow Lake |

[illegible]: Pi[illegible] Bluff Citizens Advisory Committee, pers. comm.


LIMITS OF STUDY
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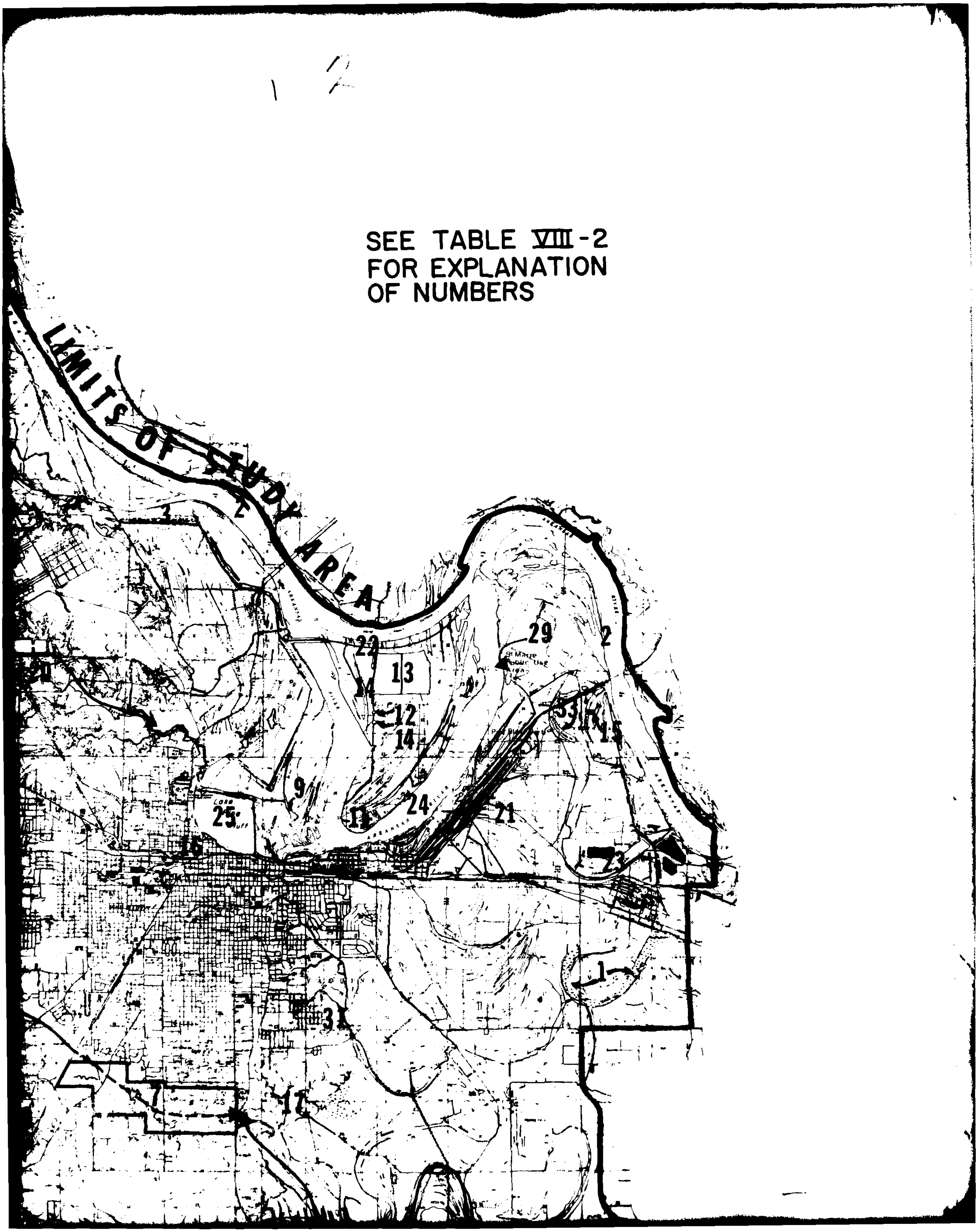
SEE TABLE VIII-2
FOR EXPLANATION
OF NUMBERS
LIMITS OF STUDY AREA
29
2
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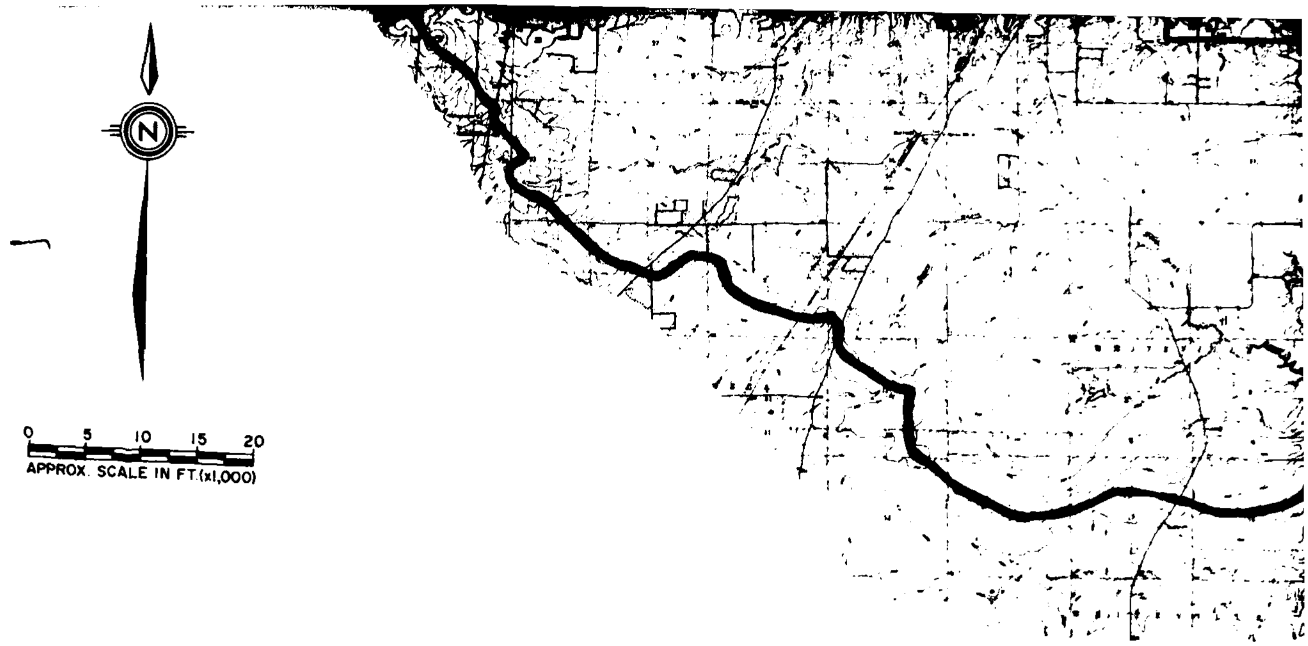
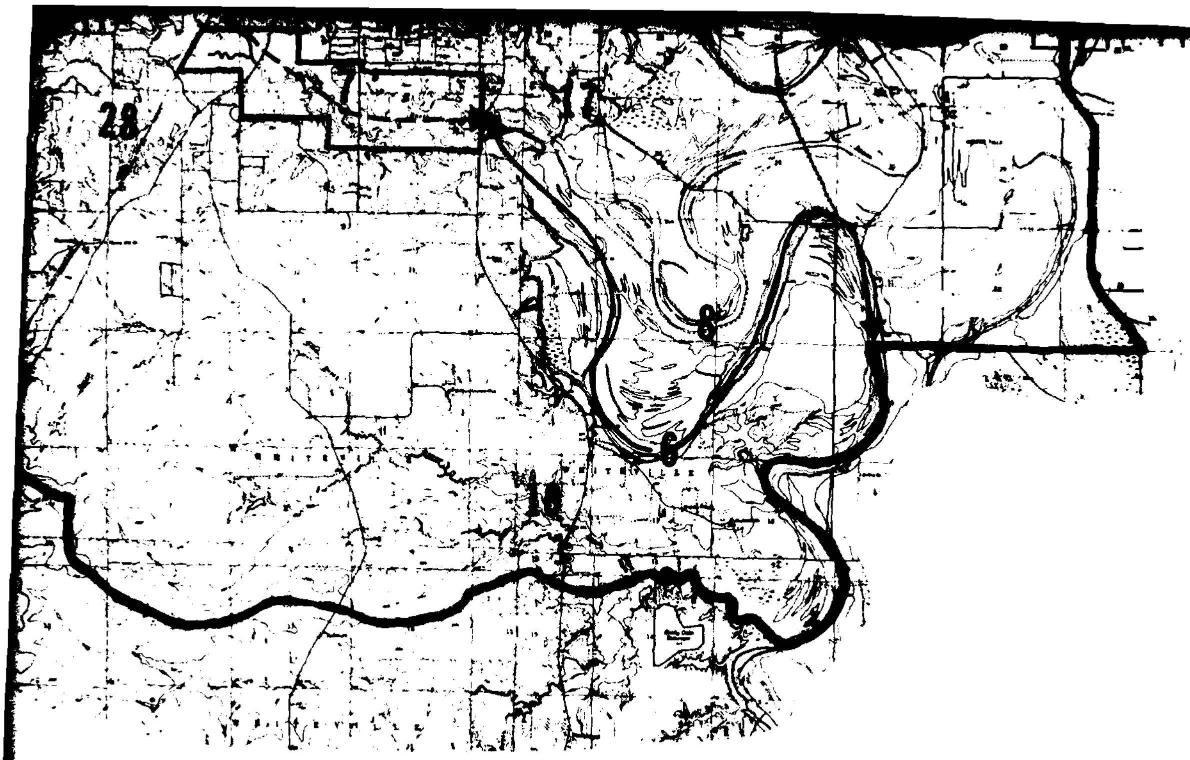



# ENVIRONMENTAL AND ESTHETIC RESOU
# OF THE PINE BLUFF STUDY AREA



THETIC RESOURCES
STUDY AREA

FIG. VIII-2

would be the institution of community improvement programs with the objective of improving the deteriorating and dilapidated structures in the area adjacent to the lake. Other improvements could be made by the construction of facilities such as boat docks, swimming and picnic areas, etc.

The realization of the aforementioned parks adjacent to Lake Pine Bluff is likely; however, other environmental potentials may be restricted by a number of factors. Poor water quality, particularly near Brumps Bayou, may restrict the use of this water body for swimming and fishing. This factor may also inhibit utilization of the area by avifauna. Another limiting factor may be bank erosion. This problem has been the responsibility of the Arkansas Game and Fish Commission; however, corrective measures have been instituted only as funds permitted. If the proposed parks are constructed along the lake's shoreline, more intensive shoreline maintenance will be required.

2. Byrd Lake.

This privately owned, 20-acre lake is located southeast of Pine Bluff (Figure VIII-2). It is in a nearly natural condition with the northern shoreline covered by a pine-mixed hardwood forest and the remainder of the area surrounded by bottomland hardwoods.

Being privately owned and having limited access, the area is not heavily used. However, those visiting the area view a diverse avifauna and fine scenery which merit consideration for preservation, restoration and/or enhancement.

Alternatives to be considered in evaluating the potential of this environmental resource are a continued natural state or future development. In both cases, the area must be purchased or leased if it is to be established for public use.

If the area is kept in a relatively natural condition with no structural development, it would have great potential as an educational resource for both botanical and zoological studies. It could also function as a valuable wildlife sanctuary.

If the lake is developed as a recreational resource, the northern shoreline could be utilized as a non-dispersed recreation site because it is well drained. The remainder of the lake could be slightly developed for activities such as fishing and nature walks.

If the area is to be utilized by the general public, special care must be taken to assure that the natural, esthetic qualities of the area are maintained.

Possible limitations preventing utilization of this environmental resource include present urban development encroachment and/or occasional flooding which inundates the southern portion. Also, because the area is privately owned, the proprietor may wish to receive recompense for public utilization and may even be unwilling to allow public utilization under any terms.

3. <u>Bayou Bartholomew Greenbelt</u>.

The proposed Bayou Bartholomew Greenbelt is a parcel of privately owned land bordering Bayou Bartholomew southwest of Pine Bluff (Figure VIII-2). The size of the area has fluctuated over the years, but the most current proposed areal extent is 547.5 acres.

The Bayou Bartholomew Greenbelt presently contains a mixture of bottomland hardwoods which are utilized by many species of wildlife. Some urban development exists within the present boundary; however, future developments will be controlled locally. Portions of the area are visited by local ornithologists.

The area is ideally located as a potential buffer area between present urban development and anticipated future urban growth (see also Section III). The greenbelt has a great potential as a park for both dispersed and non-dispersed recreational activities.

Portions of Bayou Bartholomew, within the proposed greenbelt, could be enhanced by providing easy access for canoeing, picnicking, camping and other recreational activities. This water course could provide valuable habitat for many species, thereby improving the area for birdwatching, photography, and other esthetic values (Plate VIII-2).

To achieve these environmental and recreational potentials, the greenbelt must be consolidated under single ownership either by leasing or purchasing the area. Zoning regulations would regulate use of the area.

In addition to ownership, another limiting factor is the moderate water quality of Bayou Bartholomew.

4. <u>Boyd Point Wooded Areas</u>.

The wooded areas on Boyd Point are bordered on all sides by water (Figure VIII-2) and contain a wide variety of bottomland hardwoods. Most of the area is privately owned, although one segment south of the Pine Bluff oxidation ponds is owned by the City of Pine Bluff.

The Boyd Point wooded areas provide excellent habitat for wildlife, which is abundant and often hunted.

The Boyd Point wooded area has tremendous potential as a park area because much of the area is undisturbed. Vegetation in the area is extremely diverse and is a valuable recreational resource for amateur botanists. The topography of the area, is also very diverse with small channel scars and wet areas occurring throughout the wooded community.

The Pine Bluff Parks and Recreation Department plans to develop part of the woods into a larger regional park to include access roads, bicycle paths and walkways within the wooded area, and picnicking and water-related facilities bordering Lake Langhofer. When implemented, this park will greatly enhance the recreational potential of much of the Boyd Point wooded areas.

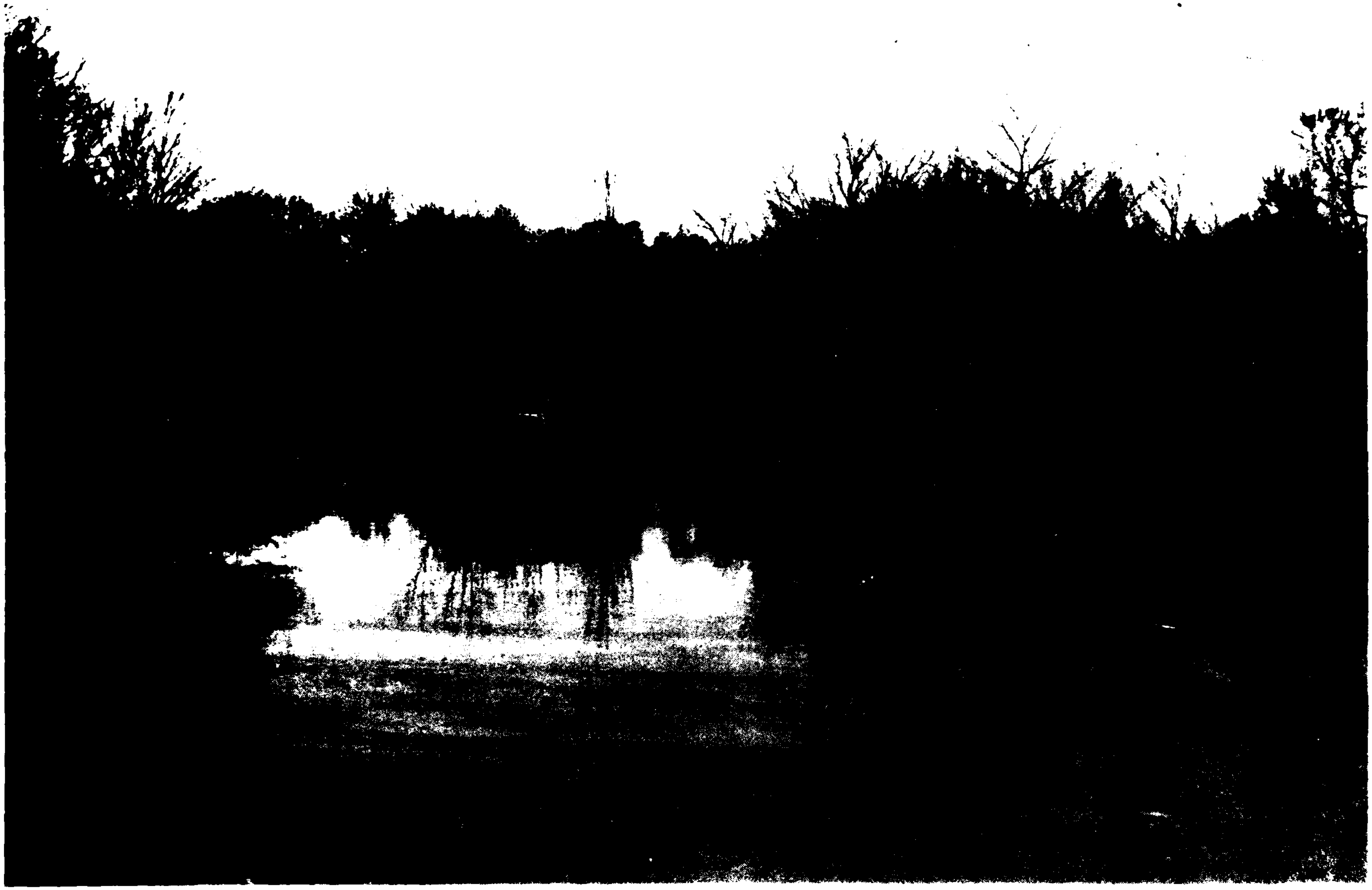


Plate VIII-2 Bayou Bartholomew Greenbelt

The principal limitation on utilization of this resource is ownership. This is not a serious handicap, however, since the City of Pine Bluff owns part of the area and the remainder is controlled by a few large landholders.

5. Pidgeon Creek.

Pidgeon Creek is a small tributary of Nevins Creek southwest of Pine Bluff (Figure VIII-2). This small, slow-flowing stream is lined with mixed bottomland hardwoods. A high natural ridge forms the west bank of one segment of the stream. Much of the stream meanders through small parcels of private property. This environmental resource provides excellent habitat for wildlife species.

Urban growth in the Pine Bluff area is occurring primarily south and southwest of the existing urban community. As a result, Pidgeon Creek could be preserved in essentially its present condition. Only small segments of the stream would be modified into parks containing very little structural development and including nature trails and picnic sites. Part of the stream could also be set aside as a wildlife sanctuary.

Limiting factors to the utilization of this environmental resource include private ownership and flooding. The area must be purchased or leased and managed by the local government. Flooding occasionally occurs in the area, but only lasts a short time.

6. Other Esthetic Resources.

There are no designated scenic rivers in the Study Area; however, the lower reaches of Bayou Bartholomew have the potential for such a designation. Likewise, there are no designated scenic roads in the Study Area; however, roads along the bluffs overlooking the Arkansas River have the potential. There are no designated wilderness areas.

## C. ENVIRONMENTAL RESOURCES (LONG FORM ANALYSIS; APPENDIX E).

To evaluate esthetic and ecological areas in the Pine Bluff Study Area, a questionnaire (Appendix E) was prepared by the Citizens' Advisory Committee (CAC) and distributed to all members of the CAC, to many local government officials and to members of the Pine Bluff Chamber of Commerce. Of the 140 questionnaires distributed, 88 were returned and evaluated. Because the sample size was small and the questionnaire distributed to a select group, the results cannot be statistically interpreted to represent the views of the population of the Study Area. Most of the people contacted were long-time residents of the community and cognizant of the attitudes of the local citizenry.

The questionnaire results indicated that each of the 35 areas warranted consideration for preservation, restoration, or enhancement. Seventy-five per cent of those responding indicated that there were nine areas that warranted special consideration. These areas are described in the following paragraphs in an order of significance, and the results of the questionnaire are presented in Table VIII-3.

TABLE VIII-3

SYNOPSIS OF THE RESULTS OF THE CITIZENS' ADVISORY COMMITTEE
ENVIRONMENTAL RESOURCES SURVEY

| Areas | Evaluations | | | |
|---|---|---|---|---|
| | Unfamiliar With Area | Need to Preserve, Restore, Enhance | | |
| | | Strongly Agree | Agree | Disagree |
| 1. Alice Brake | 50 | 16 | 13 | 9 |
| 2. Arkansas River | 1 | 59 | 17 | 5 |
| 3. Arkansas River Wetlands | 11 | 52 | 16 | 4 |
| Bayou Bartholomew | | | | |
| 4. Above Princeton Pike Road | 37 | 24 | 17 | 7 |
| 5. Between Princeton Pike Road and Olive Street | 16 | 47 | 14 | 6 |
| 6. Below Olive Street | 16 | 42 | 13 | 8 |
| 7. Bayou Bartholomew Greenbelt | 14 | 57 | 8 | 4 |
| 8. Bayou Imbeau | 44 | 12 | 20 | 5 |
| 9. Blackdog Lake | 36 | 30 | 14 | 1 |
| 10. Boggy Bayou | 55 | 9 | 15 | 3 |
| 11. Boyd Point Beach | 12 | 54 | 17 | 1 |
| 12. Boyd Point Levee Lakes | 19 | 43 | 18 | 3 |
| 13. Boyd Point Wooded Areas | 17 | 52 | 10 | 3 |
| 14. Boyd Point Sactuary (Oxidation Pond) | 27 | 31 | 24 | 3 |
| 15. Bream Lake | 63 | 11 | 4 | 5 |
| 16. Brumps Bayou | 36 | 22 | 19 | 6 |
| 17. Byrd Lake | 29 | 36 | 11 | 7 |
| Caney Bayou | | | | |
| 18. Above U.S. Hwy. 65 | 49 | 15 | 13 | 6 |
| 19. Below U.S. Hwy. 65 | 40 | 22 | 16 | 3 |
| 20. International Paper Company Wildlife Management Area | 26 | 41 | 16 | 3 |
| 21. Island Harbor Marina Road | 4 | 44 | 26 | 6 |
| 22. Johnson Lake | 37 | 14 | 16 | 12 |
| 23. Lake Langhofer | 12 | 58 | 13 | 3 |
| 24. Lake Pine Bluff | 1 | 70 | 11 | 0 |
| 25. Lake Taloha | 45 | 29 | 11 | 0 |
| 26. Nevins Creek | 55 | 14 | 11 | 6 |
| 27. Ste. Marie Recreational Area | 4 | 57 | 15 | 9 |
| 28. Sulphur Springs Area | 30 | 27 | 27 | 2 |
| 29. Taylor Lake | 50 | 15 | 21 | 2 |
| 30. Tripletts Bluff | 39 | 31 | 14 | 3 |
| 31. Wilkins Lake | 57 | 11 | 12 | 4 |
| 32. Yellow Bluff | 49 | 20 | 13 | 5 |
| 33. Yellow Lake | 50 | 18 | 15 | 3 |
| 34. Taylor Lake | 50 | 15 | 21 | 2 |
| 35. Pidgeon Creek | 64 | 6 | 11 | 4 |

Source: Citizens' Advisory Committee, pers. comm.

1. Lake Pine Bluff (See also Sections VIII.A and B.).

Nearly every response on the questionnaire indicated a need to preserve, restore, or enhance this resource (Table VIII-3).

2. Arkansas River.

Only five of the 82 responses indicated no need to preserve, restore, or enhance the Arkansas River (Table VIII-3).

The Arkansas River is utilized for local commercial and industrial navigation, flood control, and recreational activities such as fishing and boating. The river also provides water transportation between the midwestern United States and the Mississippi River.

Results also indicated that the Arkansas River should be a multi-use resource which could be utilized to promote industrial development of the area and provide recreational and esthetic enjoyment. Enhancement of this resource would involve zoning regulations which would localize industrial development and set aside areas for recreation and esthetic uses. Parks, boat launch sites, swimming facilities, and small wildlife sanctuaries could be established along the watercourse. Water quality improvement programs such as those presently established and enforced by the U.S. Environmental Protection Agency will also enhance the river. Emphasis should be placed on discharge sources upstream from Pine Bluff.

Water quality is the principal factor limiting the utilization of this natural resource and should be regulated upstream from the Study Area, if local conditions are to be improved.

3. Ste. Marie Recreational Area (See also Section VIII.A).

Only nine of the 85 responses indicated that the area did not warrant preservation, restoration or enhancement; four indicated unfamiliarity with the area (Table VIII-3). Results also indicated that this recreational facility could be enhanced by increasing its size, adding new picnicking and boat launching facilities, and providing areas for camping.

The location of this area was the principal argument presented by those responding to the questionnaire. The proximity to the Harbor Industrial Park and the Pine Bluff Port create conflicting land use conditions and is potentially hazardous for small craft travel.

4. Boyd Point Beach.

This beach is located on the southern tip of Boyd Point and is adjacent to Lake Langhofer (Figure III-2). This site is currently federally owned; however, the City of Pine Bluff intends to acquire this land and convert it into a park.

Of the 84 responses to the questionnaire, only one person felt that the area did not warrant preservation, restoration or enhancement, while 12 others were unfamiliar with the area (Table VIII-3).

This beach is heavily used by picnickers and pleasure boaters and is one of the best natural swimming areas in the Study Area. This area is well suited for water-oriented outdoor activities because water quality is generally good in this section of Lake Langhofer.

Questionnaire results indicated that the area should be cleared of litter and debris, and enhanced through the development of picnic facilities. Another noteworthy suggestion indicated by the questionnaire was the need for increased points of access to the beach area. Presently, the only access is either across Lake Langhofer or a long walk over Boyd Point.

Restricted access is the primary factor that prevents maximum use of this resource.

5. Island Harbor Marina Road.

Island Harbor Marina Road is approximately three miles long, is located on the northern end of Boyd Point (Figure VIII-2) and provides access to Lake Langhofer and the only access to Boyd Point. Over 80 per cent of the response agreed that the area should be preserved, restored or enhanced.(Table VIII-3).

Various portions of the roadway have different recreational and environmental potentials. The eastern end of the road and the area where the road forms the northwestern limit of Lake Langhofer are utilized as boat launch sites, thereby enhancing recreational facilities of Lake Langhofer. An important environmental resource area is located between the road and the Arkansas River. Many seeds transported from the west by the Arkansas River are deposited in the area after high water periods. This area is also occasionally visited by birds such as white pelicans and black skimmers. South of the road on Boyd Point is another important environmental resource area, the Boyd Point wooded areas (see also Section VIII.B.4).

One method of preserving the environmental resources near the Island Harbor Marina Road would be to establish zoning ordinances regulating development of the area. Another method would be to lease or purchase the area.

The principal limiting feature of the road itself, is that it floods during high water. The major limiting factor concerning environmental resources near the road is the lack of public ownership adjacent to its servitude.

6. Lake Langhofer.

Lake Langhofer is a former river channel of the Arkansas River with free access to the Arkansas River (Figure VIII-2). It is 17.5 miles long and encompasses about 2,000 acres.

Results indicate that of 74 people familiar with the area, only three felt that the area did not need preserving, restoring or enhancing (Table VIII-3).

Lake Langhofer is heavily utilized for all water related recreational activities. It is accessible by four boat launch sites and is also commercially important because it provides an important water transportation link between the Arkansas River and both the Pine Bluff Harbor Industrial Park and the Pine Bluff Port.

The development of the proposed regional park west of Lake Pine Bluff and on Boyd Point would tremendously enhance the recreational and esthetic potential of Lake Langhofer. Most of the responses suggest developing this proposed park. Others recommended improving fish habitat and adding channel markers for skiing and boating. Some responses indicated that the entire lake should be set aside for industrial development; others indicated that only the segment of the lake near the Arkansas River should be industrially developed. Perhaps the best means of satisfying both recreational and industrial needs on Lake Langhofer could be accomplished by establishing zoning regulations.

The principal factor which could limit enhancement of Lake Langhofer as an esthetic and/or recreational resource is the conflict between recreation and industry. It is ideally located to promote industrial development in the area; however, expanding industrial operations may diminish the value of the lake as a recreational and esthetic resource.

7. Arkansas River Wetlands.

The Arkansas River wetlands is a bottomland hardwood area near Hensley Point (Figure VIII-2) which is occasionally flooded by the Arkansas River. The area is primarily privately owned although some small parcels of land are held by the Federal government. Of the 72 persons familiar with the area, only four did not feel a strong need to preserve, restore or enhance this environmental resource.

This environmental resource is not heavily used by the public because it is privately owned and is not easily accessible. It does, however, provide habitat for many species of wildlife.

Most responses emphasized the need to preserve the area for wildlife, primarily waterfowl. This could be accomplished by purchasing or leasing the area. A conflicting suggestion was to develop the area as an industrial site because of its proximity to the Arkansas River.

The major factor restricting the area's use as a wildlife sanctuary is private ownership. If this area were to be used for industrial development, the primary limitations, in addition to land ownership, would be poor drainage, flooding, poor access by land, and lack of utility services.

8. Bayou Bartholomew Greenbelt.

The Bayou Bartholomew Greenbelt (see also Section VIII.B) is a parcel of land southwest of Pine Bluff (Figure VIII-2) which has been proposed as a park site. Four of 83 responses opposed the restoration, preservation or enhancement of the area; 14 were unfamiliar with the area.

9. Boyd Point Wooded Area.

The Boyd Point wooded area (see also Section VIII.B) consists of a diverse mixture of bottomland hardwoods bordered by Lake Langhofer and the Arkansas River (Figure VIII-2). Three of 82 responding to this environmental resource opposed the restoration, preservation or enhancement of the area; 17 were unfamiliar with the area.

## D. PUBLICLY-EXPRESSED ENVIRONMENTAL NEEDS (SHORT FORM ANALYSIS; APPENDIX E).

To evaluate the recreational, environmental and cultural needs and desires of the Pine Bluff community, a questionnaire (Appendix E) was prepared by the Citizens' Advisory Committee for the Pine Bluff Urban Water Management Study. It was distributed to numerous local organizations, clubs and large industrial concerns (Appendix E.); 887 of 2,000 forms were returned (Table VIII-4). Because the questionnaire was distributed to various groups rather than to individuals, and because the specific characteristics (i.e., sex, age, race or income) of each respondent are unknown, the results can only be evaluated within the confines of the responses received and cannot be considered as a representative cross-section of the Pine Bluff citizenry.

The responses suggest a strong need for additional fishing, hunting, camping and picnicking areas presently being satisfied primarily by Lake Pine Bluff, Lake Langhofer, the Arkansas River, Ste. Marie Recreational Area and Oakland Park. The Brumps Park and the Regional Park are both under construction and, when completed, will greatly improve the recreational facilities of the area.

The diverse topography and numerous waterways in the Study Area have very few factors which limit satisfying environmental needs of the area. Swimming, fishing and boating are limited along Bayou Bartholomew, where poor water quality during low-flow detracts from this watercourse. Hunting is limited in the Study Area by the large-scale farming operations east of Pine Bluff. These farming areas have been cleared from bottomland hardwood forests which were once important wildlife habitat. The need to preserve these habitats is presented in Section VI.B.2. and C.2.

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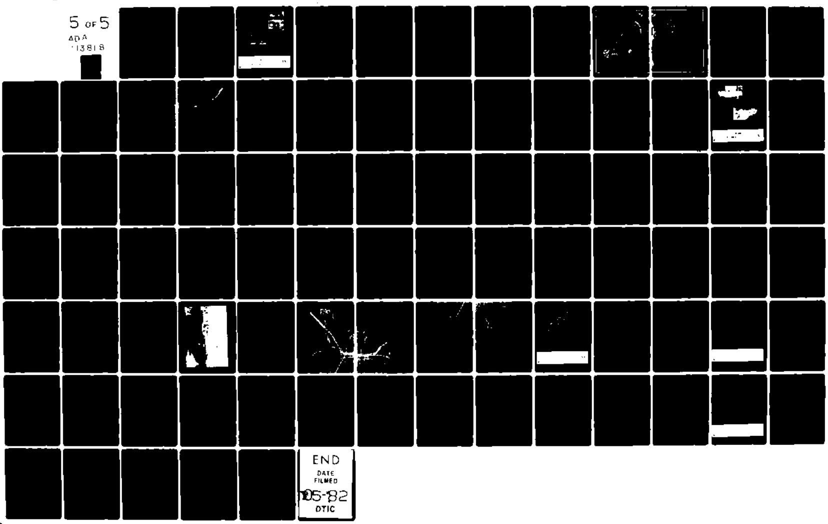


TABLE VIII-4

SYNOPSIS OF THE RESULTS OF THE CITIZENS' ADVISORY COMMITTEE
ENVIRONMENTAL NEEDS QUESTIONNAIRE

| FAMILY PARTICIPATION ACTIVITIES | NUMBER OF RESPONSES |
|---|---|
| Fishing | 650 |
| Swimming | 538 |
| Hunting | 488 |
| Picnicking | 483 |
| Outdoor Sports | 430 |
| Camping | 407 |
| Bicycling | 395 |
| Boating | 380 |
| Cultural Activities: Arts and Crafts, Music, Fairs, etc. | 376 |
| Hiking | 174 |
| Horseback Riding | 142 |
| Bird-Watching and Nature Study | 120 |
| Canoeing | 77 |
| Others | 59 |

| IMPORTANT ENVIRONMENTAL AREAS AND THEIR RANK | NUMBER OF RESPONSES |
|---|---|
| Fishing Areas - First | 660 |
| Camping and Picnicking Areas (Parks) - Second | 641 |
| Indoor and Outdoor Sports Areas - Third | 532 |
| Hunting Areas - Fourth | 513 |
| Boating and Canoeing Areas - Fifth | 394 |
| Educational Areas (Archeological and Historical Sites, Nature Trails, Environmentally Unique Areas) | 364 |
| Facilities for Cultural Activities | 327 |
| Greenbelts along Water Courses | 286 |
| Undeveloped Lands Outside of Urban Community | 285 |
| Undeveloped Lands and Open Space as Part of the Urban Community | 246 |
| Hiking Trails | 211 |
| Bird Sanctuaries | 137 |
| Bridle Trails | 99 |
| Others | 46 |

| AREAS WHICH HAVE BEEN AFFECTED BY URBAN AND/OR AGRICULTURAL DEVELOPMENT OR POLLUTION | NUMBER OF RESPONSES |
|---|---|
| Fishing Areas | 401 |
| Hunting Areas | 203 |
| Hiking Trails | 135 |
| Bird Sanctuaries | 97 |

TABLE VIII-4 (Continued)

| | |
|---|---|
| Facilities for Cultural Activities | 82 |
| Indoor and Outdoor Sports Area | 74 |
| Undeveloped Lands and Open Space as a Part of the Urban Community | 70 |
| Greenbelts along Water Courses | 70 |
| No Response | 64 |
| Boating and Canoeing Areas | 49 |
| Camping and Picnic Areas (Parks) | 44 |
| Educational Areas | 44 |
| Others | 42 |
| Undeveloped Lands Outside of Urban Area | 36 |
| Bridle Trails | 29 |

| PLACES IN NEED OF PRESERVATION FOR NATURAL BEAUTY, WILDLIFE AND/OR RECREATION | NUMBER OF RESPONSES |
|---|---|
| City Parks (Oakland, Townsend, etc.) | 112 |
| Lake Pine Bluff | 99 |
| Arkansas River | 89 |
| Greenbelt | 61 |
| Undeveloped Park Land | 55 |
| Lake Langhofer | 45 |
| Bayou Bartholomew (Not Specifically Greenbelt) | 43 |
| Small Lakes (Blackdog, Byrd, Taylor, etc.) | 41 |
| Woodlands | 36 |
| Sulphur Springs | 34 |
| Hunting and Fishing Areas | 21 |
| Streams other than Bayou Bartholomew | 21 |
| Urban and Open Green Spaces | 21 |
| Wildlife Areas | 19 |
| Historical Places | 17 |
| Camping, Hiking and Picnic Areas | 16 |
| Boyd's Point | 15 |
| Outdoor Sports Areas | 12 |
| Wetlands | 11 |
| Parts of the Arsenal | 7 |

Source: Citizens' Advisory Committee, pers. comm.

# CULTURAL RESOURCES

# IX

# IX
# CULTURAL RESOURCES

## A. INTRODUCTION.

Cultural resources include resources of archeological, historical and contemporary significance. They are fragile, limited and non-renewable portions of our total environment. In consideration of Executive Order 11593, and other pertinent legislation charging the Federal Government with "leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation", a vigorous survey in the area of cultural resources was undertaken and was closely coordinated with both State and local agencies: the Arkansas State Archeological Society, the Jefferson County Historical Commission and the Pine Bluff Department of Parks and Recreation.

## B. ARCHEOLOGICAL RESOURCES.

Knowledge of the archeological resources of the Study Area is limited. The absence of detailed information results from a lack of intensive field investigations and the area's peripheral location to centers of major cultural development.

Three centers of cultural activity bound the Study Area: northeastern Arkansas, the southern portions of the lower Mississippi Valley, and the Red River Valley System (Rolingson, 1970). Conceivably, there was cultural exchange between each of these centers, causing the Study Area to be a part of an important contact zone and zone of cultural transition. The reality of this exchange, however, has not been clearly established and the proposed importance of the Study Area is unresolved.

### 1. Pre-History.

The earliest cultural material recognized within the Study Area is of the Dalton culture which is believed to date from between 10,000 and 8,000 B.P. (Morse, 1973). It is not yet determined whether the Dalton culture should be regarded as late Paleo-Indian or as early Archaic, but the current trend considers it a terminal Paleo-Indian culture. The Paleo-Indian is the earliest recognized cultural manifestation in the New World, dating from as early as 20,000 B.P. to as late as 8,000 B.P. It is usually thought of as being characterized by the fluted points of the Clovis and Folsom types. These earliest Indians evidently were nomadic and hunted large herd animals such as the mammoth and mastodon, and extinct forms of bison (Morse, 1973).

The Paleo-Indian culture was followed by the Archaic culture which lasted until approximately 2,400 B.P. The Archaic hunters and gatherers lived in an overall environment thought to be similar to that of today. Their lifeway seems to have been based on a more complete exploitation of both animal and plant resources on a seasonal basis in relatively smaller geographic areas than was the case in Paleo-Indian times. This period is characterized primarily

by a number of stemmed and notched dart point types. No evidence of any agricultural activity is present for this period (Phillips et al., 1951; Phillips, 1970).

The Woodland Period (about 3,000 - 2,800 B.P. to 900 B.P.) reflects a more sedentary existence, probably because of the introduction of agriculture, and the first pottery production in the area. Definite religious manifestations are seen in the construction of conical burial mounds, many of which contain a number of exotic artifacts with the burials contained in the mounds (Phillips et al., 1951; Phillips, 1970).

The Mississippi Period (900 B.P. to historic contact) begins with the apparently rather sudden advent of the Coles Creek Culture. Coles Creek is marked by a number of well known pottery types, as was the earlier Woodland Period, plus the construction of large mound complexes of a religious, ceremonial nature. It is believed that the bow and arrow was introduced during the Coles Creek occupation, somewhere in the neighborhood of 600 - 800 B.P.

The Mississippian Culture which follows Coles Creek, is distinguished by the widespread use of crushed shell as a tempering agent in pottery, an attribute not seen in earlier cultural groups (Phillips et al., 1951; Phillips, 1970).

2. Sites.

At present, 22 sites are recorded within the Study Area. Indications of their cultural affiliation are presented in Table IX-1 and are based on the statements of the original reporters of the sites, including their statements of materials collected and, where possible, examination by the Arkansas Archeological Survey of these artifacts.

The 22 sites represent a time span of approximately the last 8-9,000 years. The only cultural periods not presently recognized within the Study Area are the earliest Paleo-Indian culture characterized by fluted points, and the latest Mississippian culture. The cultural stages from Dalton through Coles Creek are well represented by sites on record.

No fluted points have been reported as yet within the Study Area, and are a rarity in southeast Arkansas. One fragment of such a point is reported from the Bradshaw Brake area south of the Study Area, and it is possible that an intensive survey might produce other sites in the hill country within the Study Area.

One site (3 JE 14) is designated as possibly having a Mississippian component, but this needs verification. The Arkansas Archeological Survey earlier undertook a brief, spot check survey of the Upper Bayou Bartholomew area in southern Jefferson and northern Lincoln counties. The Mississippian culture was absent in this survey. In the entire area studied at that time, only one site was found which contained the distinctive shell-tempered pottery of this period (McClurkan, 1973).

TABLE IX-1

ARCHEOLOGICAL SITES OF THE PINE BLUFF STUDY AREA*

| Site Number | Cultural Affiliation | Possible Scientific Potential** | Location Description |
|---|---|---|---|
| 3 JE 8 | Dalton/Early Archaic | M-H | Elevated areas of wooded land northwest of Pine Bluff along east bank of Caney Bayou. |
| 3 JE 14 | Coles Creek/Early Mississippi | H | Open cotton field along Bayou Imbeau - slightly elevated ground. |
| 3 JE 16 | Woodland | L | Site stretches along natural ridge of cotton field to Bayou Imbeau. |
| 3 JE 17 | Woodland | L | Artifacts found along ridge to edge of Bayou Imbeau |
| 3 JE 28 | Late Archaic | ND | Edge of managed pine stand near large industrial area. |
| 3 JE 60 | Late Archaic/Woodland | L | At base of levee east of Caney Bayou. |
| 3 JE 64 | Woodland | ND | No access. |
| 3 JE 74 | Archaic | L | Ridge on rise in open pasture land west of Pine Bluff and north of Bayou Bartholomew. |
| 3 JE 76 | Archaic | M | Atop prominent bluff in pasture land south of Bayou Bartholomew. |
| 3 JE 78 | Archaic | ND | West side of small creek in cultivated field south of Bayou Bartholomew. |
| 3 JE 79 | Coles Creek | ND | Small rise in center of pecan orchard, near Bayou Bartholomew. |
| 3 JE 80 | Dalton/Early Archaic | H | Upper end of pasture - slightly elevated land along Boggy Bayou. |

TABLE IX-1 (cont'd)

| Site Number | Cultural Affiliation | Possible Scientific Potential | Location Description |
|---|---|---|---|
| 3 JE 81 | Dalton/Early Archaic | H | Small bluff along roadside adjacent to Boggy Bayou. |
| 3 JE 82 | Late Archaic/Woodland | ND | Center of small agricultural field adjacent to Bayou Bartholomew. |
| 3 JE 83 | Woodland (Marksville) | M | Open cotton field near Bayou Bartholomew. |
| 3 JE 84 | Archaic | ND | Elevated rise of pasture land along Bayou Bartholomew. |
| 3 JE 85 | Late Archaic/Woodland | ND | No access. |
| 3 JE 101 | Coles Creek | ND | No access. |
| 3 JE 102 | Coles Creek | ND | Along ridge in agricultural field near Bayou Bartholomew. |
| 3 JE 103 | Woodland | ND | Unindated northern half of oxidation pond. |
| 3 JE 104 | Archaic | O | Natural ridge of fallow field north of Bayou Bartholomew. |
| 3 JE 105 | Archaic | ND | Under new subdivision road adjacent to Bayou Bartholomew. |

SOURCE: Arkansas Archeological Survey

* Detailed locations of the archeological sites are omitted as requested by the State Archeological Society.

** See Text for explanation.

The lack of Paleo-Indian sites is not particularly surprising since they are not common, but the apparent absence of a Mississippian occupation is very definitely a perplexing problem.

3. Scientific Potential.

As many of the 22 sites have not been visited by the Arkansas Archeological Survey, the only valid criterion for "scientific potential" of a site is the current condition of that site; how little or how much the site has been disturbed and altered by subsequent activities. With the lack of recent examination, any statement of possible scientific potential must be regarded as highly speculative. The statements of potential made in Table IX-1 should not be considered a scientific assessment. Until further field work, no further assessment can be made. The categories of possible potential (Table IX-1) are:

O - site destroyed or so disturbed as to render it useless for further study purposes.

L - low potential; site badly disturbed.

M - moderate potential; data indicates site damaged to some degree, but may still retain some potential for investigation.

H - high potential; data indicates little significant damage to site, or site is of such a nature as to make further investigation desirable.

ND - no data.

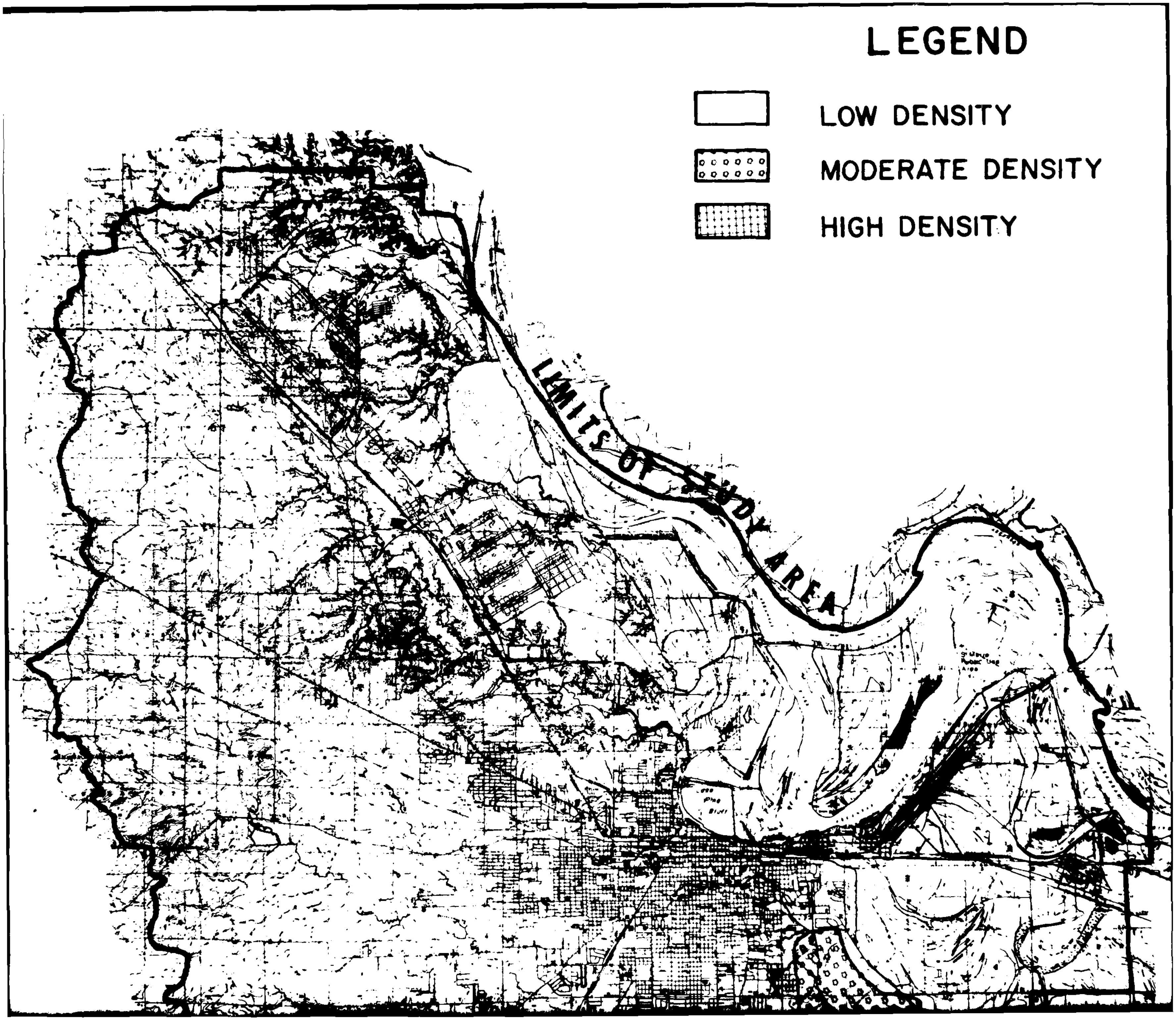
4. Site Densities.

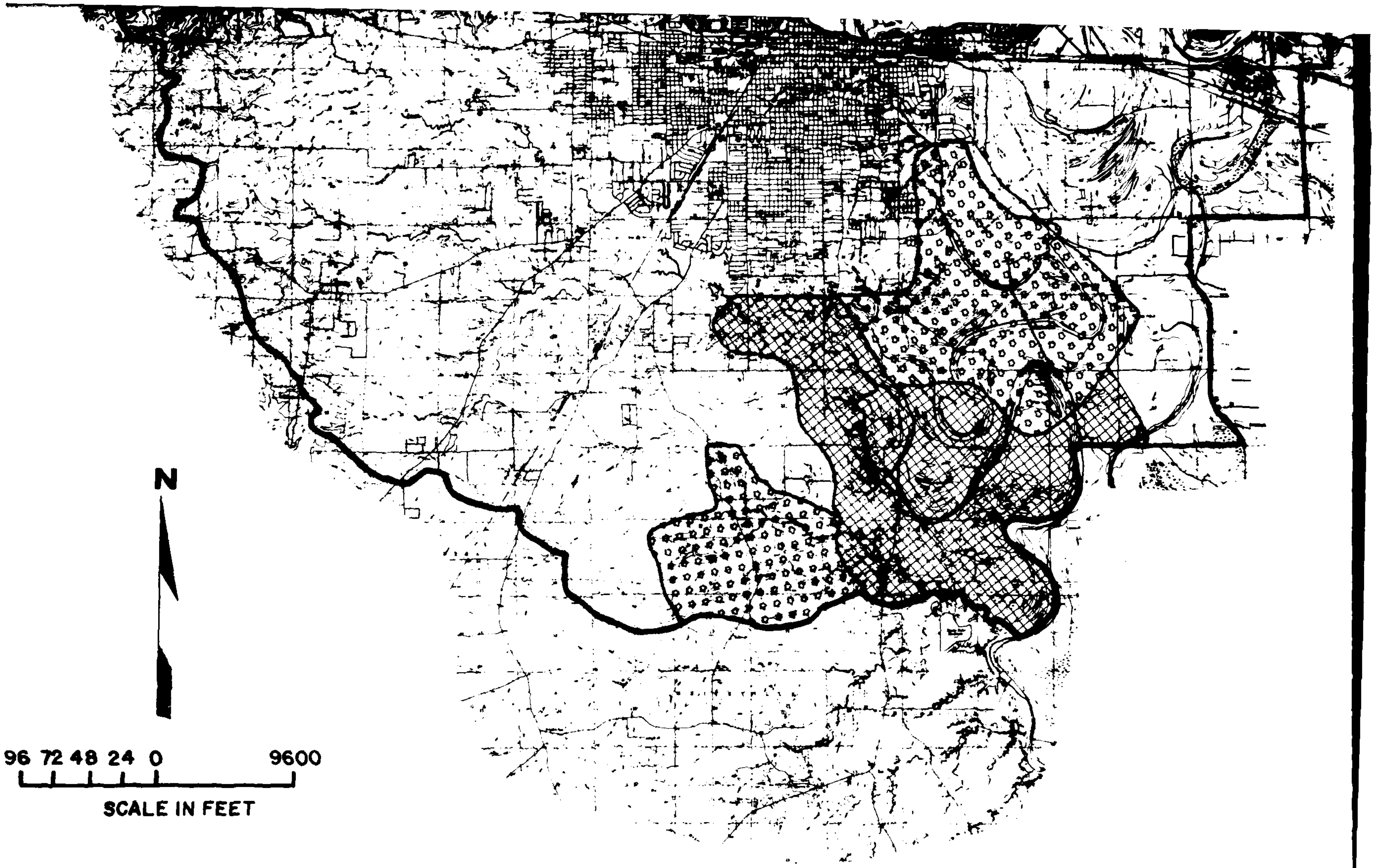
Figure IX-1 indicates the site densities for the Study Area. The areas delineated on this map have been determined by currently available site data, survey work in the Study Area and general knowledge based on work in the Gulf Coastal Plain in Texas, Louisiana and Arkansas.

a. Low Density Areas.

Low density areas include the frontage outside of the present Arkansas River levee which has been cut, filled, flooded and so drastically altered that the presence of archeological sites is considered nil. Another area of low density is that of rolling upland hills with no perennial water courses, no known springs, and somewhat removed from the waterways which dissect the hills. This region is presently in moderate to heavy timber growth, spotted with some pasture acreage. The bulk of urban Pine Bluff is also so designated. It is not feasible to state there are no sites in Pine Bluff when this was obviously a highly desirable location, but the very presence of the city makes site location extremely difficult. Sites may well be located during the course of urban development or urban renewal.

Areas of scattered sites (known or probable) encompass two different areas: the delta region to the east of the City of Pine Bluff; the hill country north, west and south of Pine Bluff, along the terraces of the perennial waterways.


LEGEND
LOW DENSITY
MODERATE DENSITY
HIGH DENSITY
LIMITS OF STUDY AREA
Pine Bluff




ARCHEOLOGICAL SITE DENSITIES

FIG. IX-1

The delta region has been subjected not only to the channeling of the Arkansas River, but also to seasonal flooding prior to the erection of the levee. It has also been in cultivation for a considerable span of time; some tracts probably for well over a hundred years. Few sites are currently known in this area at present, but systematic intensive surveys will assuredly increase the inventory. Scattered sites are recorded in hilly regions and further systematic surveys of these terraces will probably significantly increase the known site density.

b. Moderate Density Areas.

Areas of moderate density are projected in only two relatively small areas. One is on the delta which has been searched for years by local amateurs and on occasion by the Arkansas Archeological Survey. Only a few sites have been discovered there. Future intensive surveys will probably increase the number of recorded sites in this area, but past work by reliable amateurs suggests a moderate site density rather than a high density. The other projected area of moderate density is the upland region, slightly west of the escarpment near the headwaters of Boggy Bayou. This seems to be an archeological transition zone where some sites have been reported previously. It was a favorable habitation area.

c. High Density Areas.

Areas of high density occur along the escarpment overlooking the delta and the adjacent delta; a number of sites have already been located. Because of the present density of known sites, other sites are reasonably certain to exist.

## C. HISTORICAL RESOURCES.

For the past few years, members of the Jefferson County History Commission have been accumulating data relative to structures of historical, architectural and cultural significance within Jefferson County. One of the basic purposes for compiling this data was to determine which of the numerous structures extant within the county were most acceptable for nomination to the National Register of Historic Places.

In 1972, two architecture students from the University of Arkansas at Fayetteville made a study of the section of Pine Bluff containing the majority of the existing historic structures. This study was commissioned and subsidized by the County History Commission, and was entitled Historic Preservation Through Urban Planning. Much of the data presented in this report was taken from this work.

1. Historic Background.

Pine Bluff is aptly named since it occupies the first of a series of bluffs on the south side of the Arkansas River. This bluff, adjacent to the rich bottomlands of the Arkansas River delta, afforded protection from seasonal flood waters and an ideal location for one of the earliest settlements in the state.

Joseph Bonne is given credit as being the first settler in the area, arriving in 1819, and naming the locale Mt. Maria. During his early years at this location, other settlers are believed to have come into the area, such as John Noble, the Scull brothers, John Pullen and others. About 1830, the name was changed to Pine Bluff to commemorate the first exceptionally high ground encountered ascending the river.

Although the town was not incorporated until 1839, as early as 1832 it had been selected as the county seat for the newly formed Jefferson County. The need for a permanent structure to house the county government prompted the county commission to order the construction of the courthouse in 1838, which is still in use and the oldest functioning courthouse in Arkansas.

During the early and middle 1800's, the Arkansas River was the main thoroughfare of commerce, and the towns that appeared on its banks, such as Arkansas Post, Pine Bluff, Little Rock, Fort Smith and others, soon became thriving ports and focal points, not only of commercial enterprise but of social and political activity. In this respect, Pine Bluff was certainly no exception. Occupying, as it does, high ground relative to the river, it afforded its inhabitants a unique vantage point unaffected by the all too predictable seasonal floods of the Arkansas River.

The Civil War then came to Pine Bluff. An unsubstantiated story has it that local people fired a shot with a small cannon at a United States Navy gunboat on the river prior to the engagement at Ft. Sumter. Military records show, however, that Pine Bluff was occupied by Federal troops on September 15, 1863, at the request of the local citizenry. If this were not unique in itself, within a month of the occupation of the City, the local men had formed a company of State militia which was attached to the Federal troops. Captain R. Murphy commanded the State contingent and was under the overall command of Colonel Powell Clayton. Colonel Clayton later was to become Reconstruction Governor of the State.

On October 25, 1863, Confederate troops under the command of General Marmaduke attempted to occupy Pine Bluff, but withdrew after an indecisive engagement. During the skirmish, cannon fire from Federal strongholds along the river damaged the courthouse and other structures, some of which are still standing.

In the 1870's, the railroads expanded west and afforded a new, rapid, overland form of transportation for both people and goods. Once thriving river towns like Arkansas Post were doomed by the rails. The river no longer acted as the main artery and new towns grew up along the rails. Pine Bluff was more fortunate in that it was both a river and a rail port.

Probably the greatest period of growth of Pine Bluff during the 19th century was the period from 1870 to 1900. It was also during this period that some of the more beautiful homes were built, reflecting the influence of architectural styles prevalent in the country and also attesting the affluence of the City and its residents.

The early years of the 20th century saw the continued growth of the City as a focal point for agriculture and the rapidly growing forestry-based industries. This industrial growth has continued and, in recent years,

significantly increased. With the opening of the Arkansas River as a navigable stream, the position of Pine Bluff as the first port city upriver from the Mississippi promised even greater industrial expansion and concomitant importance in the state.

Vital contributions to community growth and development must be given the ethnic groups which have chosen to make Pine Bluff their home. The black population of Pine Bluff has seldom been less than half the total, and frequently more. During the Civil War, the local company of State militia was composed of both black and white members. Pine Bluff elected two black representatives to the state legislature after the Civil War, and retained them after Reconstruction was over. In addition, there are significant populations of Bohemian, Chinese, Greek and Italian origins. This is not to negate the importance of other nationalities and their contributions, but the above mentioned are of sufficient number to be considered viable sub-communities.

Religiously, Pine Bluff is a fortunate admixture of Catholic, Protestant and Jew with a slight sprinkling of Hindu, Bhuddist and Muslum. The earliest Catholic congregation in the State was that of St. Mary's Church, north of the Arkansas River in Jefferson County. The church building is listed on the National Register, but it is not within the limits of the Study Area. The oldest Episcopal Church in Arkansas is Trinity Episcopal in Pine Bluff, also listed on the National Register. Although the original Temple Anshe Emeth is no longer standing, the Anshe Emeth congregation is the oldest organized Jewish congregation in Arkansas.

Educationally, Pine Bluff has long been a leader in the state. The first school was opened in 1839, under the auspices of St. Mary's Church, but the public school system did not begin until after the Civil War in 1869 (Martin and Ware, 1971). Today the city houses not only an excellent public school system, but several parochial schools of various denominations, a private academy, the Pines Vocational-Technical School, and the University of Arkansas at Pine Bluff (formerly Arkansas A M & N College) which was founded in 1871, as one of the first land grant colleges in the state.

2. Architectural Background.

Early settlers on the western frontier utilized the materials available, with the result that the architectural beginnings of any settlement were usually log cabins and dog-trot style houses. In 1838, the county commissioned the construction of the Jefferson County Courthouse, and this could be considered the beginning of the stylistic development of architecture in Pine Bluff. Such colonial or pioneer house forms as the log cabin and dog-trot house were to go out of style because of the influx of more refined styles prevalent in the country at the time. It is not known whether such styles were principally brought up the river from New Orleans, or overland from Kentucky and Tennessee, but most likely an equitable combination of both of these sources is responsible for the development of style in this area. Excellent examples of most styles characteristic of the architectural development of the United States are to be found in Pine Bluff.

3. Historic Structures.

The structures discussed in this report consist, for the most part, of residences and commercial and religious buildings within the City of Pine Bluff.

Although the watershed Study Area extends for some distance to the north, west and south of the City, less work has been done outside the City than would be desirable; a condition which will be rectified by further survey and study.

Of the total 136 historical structures occurring on the Master List of Pine Bluff as drawn up by the Jefferson County Historical Committee, 36 have been extrapolated on the basis of particular historical or archeological significance (Figure IX-2). The total Master List is appended (Appendix E).

In order to facilitate finding the position of the structures on Figure IX-2, they have been arranged according to location. The streets of Pine Bluff have been named so that east-west oriented streets south of the courthouse are numbered, increasing toward the south; north-south oriented streets west of Main are named for trees, while the north-south streets east of Main are named for states of the Union. There is no First street; what would be First Street bears the name of Barraque (Bar-a-kay).

a. Sites in the National Register.

The following properties are currently listed in the National Register of Historic Places. Nomination forms are currently underway for a number of the other properties. The County History Commission has a standing committee for evaluation and nomination of historic properties to the National Register.

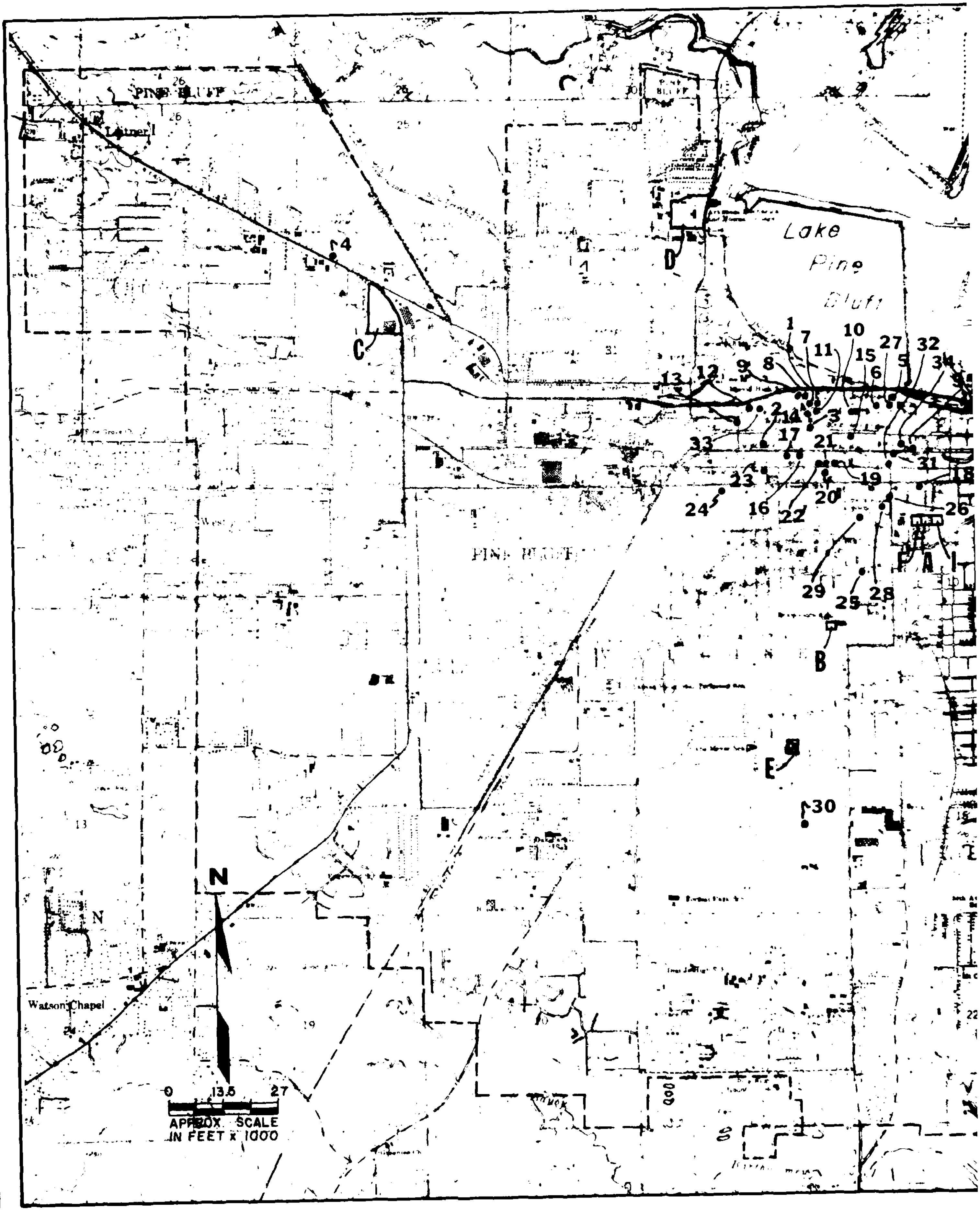
(1) Hudson-Grace-Borreson Home, 719 West Barraque (1)*.

This home evolved through a succession of owners from a simple two room cabin to the elaborately decorated two story house of today. The original portion was built about 1830 by William Woodruff. It was expanded and re-modeled in 1960 by Marion Hudson, and purchased in a tax auction by Colonel W.P. Grace in 1968. The house is a mixture of Classic, Victorian and French colonial styles, a unique building in Arkansas. It is in excellent condition. Although the interior has been extensively modified to suit its present owners needs, the exterior design integrity has been retained. The significance of the structure lies in its mixture and the blending of architectural styles and qualities. It was placed on the National Register in 1972.

(2) Du Bocage, 1115 West Fourth (2).

Du Bocage is the popular name for the home built by Judge Joseph W. Bocage in 1866. It was constructed of lumber cut and milled on his land. Judge Bocage was one of the county's most prominent citizens of his day, and his home reflected transitional features of the Greek Revival and Victorian architectural styles. The Judge was active both in politics and business in the area and was one of the early historians of the region. The house is of significance not only from an architectural standpoint, but also historically as the residence of one of the more important local residents of past years. The home is currently owned and maintained by the Pine Bluff Optimist Club, which has refurnished the house with period pieces and offers tours of the home. It was placed on the National Register in 1972.

* Index for Figure IX-2



PINE BLUFF
Lake Pine Bluff
PINE BLUFF
Watson Chapel
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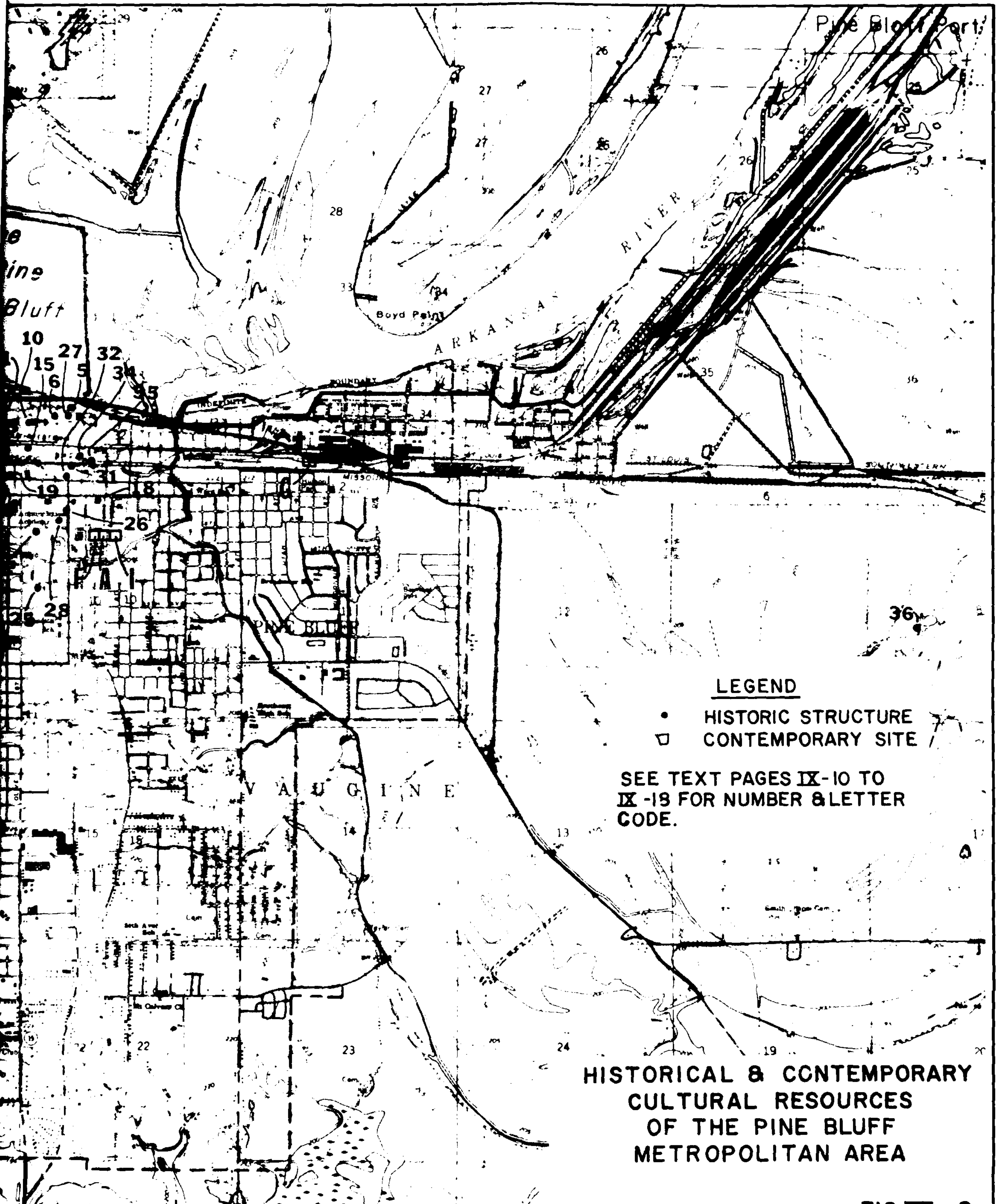



HISTORICAL & CONTEMPORARY CULTURAL RESOURCES OF THE PINE BLUFF METROPOLITAN AREA

FIG. IX - 2

(3) Trinity Episcopal Church, 703 West Third (3).

This is the oldest Episcopal Church in Arkansas. Construction was begun in 1863 but was interrupted by the Civil War. It was not completed until 1871. It is a simple Gothic Revival structure with buttressed masonry walls supporting a roof with two pitches, steep over the nave, shallow over the aisles. Stained glass, Gothic-style windows each contain unique illustrations and inscriptions. The building is in excellent condition and has been in continual use by its congregation since its completion. It was placed on the National Register in 1974.

(4) Dollarway Road (4).

The Dollarway Road was built as a result of Act 164 of the Arkansas Legislature. The first directors of the newly formed Highway Department met in March, 1913, and let the contract for this concrete road in July of that year. It was originally 22.2 miles in length, running from the Pine Bluff city limits north and west to the Jefferson-Grant county line. It was the first concrete highway in the state, and possibly one of the first in the nation. Oddly enough, the official ribbon cutting ceremony was more of a protest meeting than a celebration. This was due to the tax levied on the farmers through whose land the road ran. They were unhappy because they felt the road was too hard on their horses, their wagons and their pocketbooks. The road itself is no longer serviceable and has been superseded by U.S. Highway 65. Indeed, most of the original Dollarway Road no longer exists. There are, however, short stretches of it still extant and the State Highway Department nominated one such portion, north of the Plainview entrance to the Pine Bluff Arsenal, and containing the old bridge over Caney Bayou, to the National Register. It was placed on the National Register in 1974.

b. Historic Sites Not Listed on the National Register.

(1) Jefferson County Courthouse (5)*.

Located at the north end of Main Street on the north side of Barraque, the structure was begun in 1840 and is the eldest functioning courthouse in the state. The original dome on the front was destroyed by Federal cannon fire during the Civil War, and the structure was rebuilt afterward. Additions have been made through the years, but the original structure is still extant and forms the inner core of the present building.

(2) R.M. Knox Building, 223 West Barraque (6).

Built about 1880, it is an iron-front-type building typical of the commercial architecture of the day and one of the few remaining unaltered commercial building left along Barraque Street.

(3) Trulock-Gould House, 704 West Barraque (7).

Built about 1875, this home has an unusual front door with semicircular, arched transom and sidelights; the steeply pitched roof has gables with bargeboard trim. It combines several architectural styles and is in an excellent state of preservation.

* Index for Figure IX-2

(4) Houston House, 803 West Barraque (8).

Built in the 1890's by R.S. Thompson. It was later bought by E.B. Houston who came to Pine Bluff as a youth prior to the Civil War. He was a successful merchant and real estate developer and helped start the first library. Mrs. Houston was one of the early collectors of historical information in the City. The home is a good example of Victorian architecture and worthy of preservation.

(5) Bell-Robinson-Triplett House, 811 West Barraque (9).

Built in 1852 by Samuel Calhoun Roane as a wedding gift to his daughter, Juliet Calhoun Roane Bell. This was the first brick home in Pine Bluff. It is a surviver of the Battle of Pine Bluff, October 25, 1863 and suffered a cannon ball through both walls. It was weakened so that a steel cable now helps support the structure.

(6) Old Telephone Company Building, 401 West Second (10).

Built about 1907, it was one of the first buildings built exclusively to accommodate a modern telephone system. It was doubled in size in the 1920's and is in excellent condition.

(7) Roth-Rosenweig House, 717 West Second (11).

Built in about 1891 by Lewis Roth, this two story frame house has a three story round tower at its southwest corner. A single story verandah shelters the front and sweeps around the base of the tower. This house has been recently restored to its original condition.

(8) Schober House, 1205 West Second (12).

The exterior of the house presents many features typical of stick style of architecture, including steep, complex roofs, a scissor truss gable ornament and an extensive verandah with ornate "gingerbread" woodwork. The house is in good condition.

(9) Collier Lee House, 1300 West Second (13).

Built about 1894, an outstanding example of Queen Anne Victorian architecture. It is in excellent condition and presently occupied. The Lee family were early settlers of Pine Bluff. They came to the City prior to the Civil War.

(10) 609 West Third (14).

This unimposing one story frame house was the first Rabbi's home in Pine Bluff. Built about 1877, it adjoined the first Jewish synagogue which has since been removed.

(11) Hammett House, 320 West Fourth (15).

This house was built in 1883, has been restored and is currently in good condition. It served for many years as the Holderness Funeral Home, and was later made into an apartment house. The exterior is the same now as when it was built.

(12) 802 West Fourth (16).

Built in 1886 by Charles H. Triplet, who came to Pine Bluff in 1846 and held a number of county offices in the post-war period of Pine Bluff.

(13) Ferguson-Nash House, 902 West Fourth (17).

This house was built in 1885 by C.M. Ferguson, a prominent Pine Bluff businessman. The two story ell-shaped structure has balconies on the north and east elevations with an ogee arch trimmed with ornate spindle work. This Queen Anne Victorian style house is in good condition, and was the childhood home of Martha Mitchell, wife of the former U.S. Attorney General.

(14) Plummer-McAlmont-Noell House, 216 East Sixth (18).

Probably the oldest, still standing house in Pine Bluff, it was built in 1844, in the dog-trot style and put together with wooden pegs. Though altered, the house retains many of its early features.

(15) Peter Paul Byrd Home, 619 West Fifth (19).

Built in 1902 - 1903, the interior is of architectural significance, and the house is built strictly of pressed brick. It is "one of a kind" in Pine Bluff and, hopefully, the house will be preserved. Peter Paul Byrd was the son of the well known artist, John Henry Byrd.

(16) M.A. Austin Home, 702 West Fifth (20).

An excellent example of Greek Revival architecture, built about 1895 by Austin, an early prominent lawyer in Pine Bluff.

(17) Gans-Bluthenthal House, 713 West Fifth (21).

The original small house was the first rectory for the Trinity Episcopal Church. Gans bought the house in 1890 and made it into a one story Victorian house with a round cupola. In the early 1900's, a second story was added and the cupola raised.

(18) Barrow House, 715 West Fifth (22).

Built about 1890, an excellent example of Greek Revival architecture. This is the historical home of a pioneer Jefferson County planter. It is in excellent condition and should be preserved for future generations.

(19) Prigmere-Martin House, 1104 West Fifth (23).

This house has remained in the family since it was built in 1873 by Captain George Prigmere. Double columns support the front porch of this Greek Revival style home. This two story white frame house has been well preserved for the last 100 years.

(20) R.M. Knox House, 1504 West Sixth (24).

This is an excellent example of Eastlake Victorian architecture. The two story frame structure was built in 1885 on an ell-shaped plan by R.M. Knox, a prominent Pine Bluff businessman.

(21) MacMillan-Wilkins-Dilley House, 400 Martin (25).

This house was built in 1903, by H.A. MacMillan, President of Sawyer-Austin Lumber Company. It is an excellent specimen of Frank Lloyd Wright's Prairie-style of architecture.

(22) Shrine Temple, 618 Main (26).

This was the first Shrine Temple in Pine Bluff and is an excellent example of Sullivanesque-style architecture which appeared in the period 1890-1915. This structure was built in 1907.

(23) Hood Building - Old Merchants and Planters Bank, 100 Main (27).

Built in 1894 on the site of the first bank in Pine Bluff, this structure is a classic example of Chateauesque-style architecture.

(24) Drake House, 625 Pine Street (28).

Built in the 1870's or perhaps somewhat earlier by riverboat Captain L.P. Drake, it was moved from its original location at 120 West Sixth in 1910.

(25) Gip Taylor House, 801 Walnut (29).

This house was built in 1893 by John Gipson Taylor, a Pine Bluff attorney. It has a symmetrical plan with all rooms flanking a central hallway. It features a steep hipped roof with a captain's walk on top. Though the house has been recently converted into an office building, the exterior features have been preserved.

(26) Tomlinson Home, 2805 Elm (30).

Birthplace of the Arkansas State Flag. Willie K. Hocker stated that while visiting the Frank Tomlinson's in late 1912, she conceived the idea for the state flag and drew the design with crayons in one of the upstairs bedrooms. The design was adopted as the official flag on February 26, 1913. The first flag was made by Miss Hocker in the same room where she created the design. The home is in excellent condition.

(27) St. Peter's Church, 1507 State (31).

This was the first Negro Catholic Church in the State of Arkansas and was dedicated on November 1, 1903. For many years, the Colored Industrial Institute was operated in conjunction with the church. It is also of architectural interest.

(28) Hotel Pines, 422 Main (32).

Built in 1913 by Monks and Ritchie, local contractors, and decorated by Paul M. Herrwagen of Fayetteville, one of the State's most prominent interior designers. Built of pressed bricks, it has been one of the City's landmarks since its erection. Recently, it was bought by a local group who plans to convert it to other uses. At the time it was built, it was considered one of the most elegant hotels in the country.

(29) Old Temple Anshe Emeth, 1001 West Second (33).

This was the second synagogue built by the Anshe Emeth congregation in 1902. The building is of architectural importance as an excellent example of Richardsonian-Romanesque-style of design. It now serves a Black congregation as the First Baptist Church, though the original stained glass windows depicting Jewish motifs are still present.

(30) Masonic Lodge Building, Fourth and State (34).

This building was built about 1903 and was the first Black Masonic Lodge building in the State of Arkansas. It is an excellent specimen of the Commercial-style of architecture of the period.

(31) Missouri Pacific Station, Fourth Street, between State and Alabama (35).

Built in 1906 by the Iron Mountain Railroad, which later became the Missouri-Pacific, this style of architecture is fast disappearing. The structure now belongs to the City and plans are being made to convert it to other uses.

(32) Chalmette, Six Miles East of Pine Bluff (36).

This interesting structure is the center of some controversy regarding its date of construction; some sources state it was built as early as 1840, while others feel its origin was closer to 1890. Regardless, it is an interesting architectural study.

## D. ARCHITECTURAL STYLES.

The previously listed structures represent many of the architectural styles present in Pine Bluff. Many of them are linked not only with local history, but with events and people of larger scope. The development of architecture, as it is represented in Pine Bluff, is as integral a part of the history of the area as the politics and events of past times. The architectural styles well represented in the City are as follows.

| | |
|---|---|
| Greek Revival | 1800-1840 |
| Medieval Revival | 1820-1850 |
| Renaissance Revival | 1830-1860 |
| Second Empire Victorian | 1860-1876 |
| Queen Anne Victorian | 1860-1880 |
| Eastlake | 1870-1885 |
| Chateauesque | 1870-1890 |
| Richardsonian Romanesque | 1870-1890 |
| Shingle Style | 1880-1900 |
| 2nd Renaissance Revival | 1890-1900 |
| Commercial Style | 1890-1910 |
| Sullivanesque | 1890-1915 |
| Neo-Classic Revival | 1890-1920 |
| Late Gothic Revival | 1895-1915 |
| Prairie Style | 1900-1920 |
| Bungaloid | 1900-1920 |

E. CONTEMPORARY CULTURE.

An active contemporary cultural entity in the City of Pine Bluff is the Southeast Arkansas Arts and Science Center and its associated "Little Firehouse." Hestand Stadium also offers various forms of entertainment which appeal to all age groups. The University of Arkansas in Pine Bluff offers opportunities for both cultural and educational advancement. Also, churches in the area (notably the South Side Baptist Church) fill a contemporary need for non-secular oriented culture. Contemporary cultural resources follow.

1. Contemporary Resources.

a. Southeast Arkansas Arts and Science Center (A)*.

Founded in 1969, this center offers tours, classes, film series, workshops, theater, art festivals and extension programs for persons in the Pine Bluff urban area and surrounding communities. Three outstanding programs are offered at the Southeast Arkansas Arts and Science Center: 1) art awareness; 2) fall festivals, and 3) spring festivals.

The Art Awareness Program primarily introduces students to art. The Fall Festival is oriented towards student and adult education through involvement in the arts, media, music, dancing, visual art and theater. Activities at the Spring Festival are "learn-by-doing" exercises for children. In terms of attendance, the Fall Festival of 1973 drew over 6,000 people; the Spring Festival attracted 2,718 youngsters (Jefferson County Historical Commission, pers. comm.).

Future expansion of the Southeast Arkansas Arts and Science Center depends on availability of new space, and the findings from a special committee in which future programs and their ability to draw people from the region and out-of-state are being debated.

b. Little Firehouse (B).

The Southeast Arkansas Arts and Science Center also operates the "Little Firehouse" at 1516 Laurel Street. The activities held there are oriented mostly towards crafts work, photography and art education for all age groups. Theatrical productions are also performed at the "Little Firehouse." Mr. and Mrs. Henry Gregory established the "Little Firehouse" at a community cultural center in 1954.

c. Hestand Stadium (C).

Hestand Stadium serves as the site for the Southeast Arkansas Livestock Show and associated entertainment such as carnivals, side shows and the like. Also held there are various rodeos, horse shows, wrestling matches, and gospel and country music gatherings.

* Index for Figure IX-2

d. University of Arkansas at Pine Bluff (D).

The University of Arkansas at Pine Bluff has a diversity of cultural resources, from art exhibits to concerts to theatrical productions. Because of its incorporation into the University of Arkansas system (1972), it will probably continue to develop and expand its facilities.

e. South Side Baptist Church (E).

With one of the largest congregations in the Pine Bluff area, the South Side Baptist Church plays a viable role in offering non-secular activities for its members. While not generally thought of as contemporary cultural resources, churches such as South Side Baptist exert a strong influence on the cultural background of a community.

f. Pine Bluff Civic Center (F).

Occupying a full city block in the area of 10th and State streets, the Civic Center serves a multitude of community needs. Among the entities contained here are the Police and Fire departments, city government offices, a 96,000 volume library and the aforementioned Southeast Arkansas Arts and Science Center. The Civic Center was designed by Edward Durell Stone and was dedicated on May 9, 1968. Total cost of the Greek-style structure was $3.2 million.

g. U.S. Highway 65 Expressway (G).

Dedicated on August 29, 1974, the $14 million, 6.5 mile section of U.S. Highway 65 offers both thru and local traffic a much quicker, less congested corridor through the City of Pine Bluff. An additional $1 million was spent on pavement and bridge improvements on adjacent U.S. Highway 79.

h. "Free Bridge" (Not Indicated on Figure IX-2).

Built to accommodate increased traffic, the U.S. Highway 79 "Free Bridge" was completed in 1971 at a cost of $7 million.

i. Convention Center (I).

A 140,000 square foot Convention Center is now undergoing construction. The projected completion date and cost are May, 1976, and $5.77 million. Planned entities with the Convention Center include a 2,100 seat auditorium and theater, a 7,300 seat arena and a 12,000 square foot common lobby. Planned activities at the Convention Center include art exhibitions, live entertainment (rock shows, country and western music shows and the like) and indoor spectator and competitive sports programs. Associated attendant structures such as motels, specialty shops and entertainment spots will probably accompany the Convention Center by the time the dedication ceremony is realized.

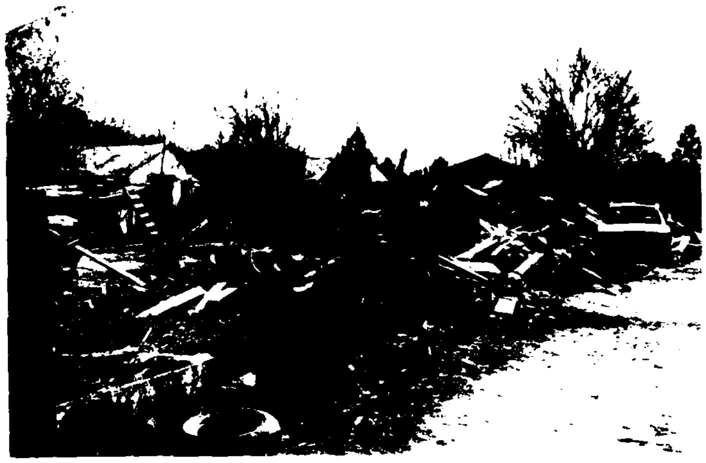
j. 28th Street Overpass and Widening (J).

As 28th Street is a heavily travelled Pine Bluff artery, the St. Louis Southwestern railroad crossing has long congested traffic in that area. Traffic moving through the area should move much more freely after construction of an overpass above the railroad and street widening both east and west of that site.

2. <u>Relationship Between Cultural Resources and the Study Area Environment</u>.

Inevitable urban, industrial and agricultural developments pose potential threats to the archeological and historical resources of the Study Area. Cultural awareness of the importance of preserving historical structures in the Pine Bluff area has taken an upward trend in recent years and the concerted efforts of a few have resulted in a master list of historically important structures and an overall community effort to preserve their heritage. This preservation trend is expected to continue insuring cultural awareness for the future.

The archeological community has suffered greatly from the lack of public concern and knowledge of the past. The archeological resources will suffer the greatest destruction from indifference and urban, industrial and agricultural developments which may take precedence over the educational and scientific potential of the archeologic resources. When sites are designated as culturally or historically significant (National Register of Historic Places), they are protected from development which would infringe upon their historic or cultural value.



# SOCIOECONOMIC ELEMENTS

# X

# X
# SOCIOECONOMIC ELEMENTS

## A. SOCIAL CHARACTERISTICS.

Due to the lack of data describing the specific "Study Area", statistics for the population will be given for Jefferson County and the Pine Bluff urban area. It should be noted that of the people in Jefferson County living outside of the Pine Bluff corporate limits, more than half live within the Study Area. That is, of Jefferson County's 85,329 residents, 57,389 live in Pine Bluff and the remaining 10,019 people live outside of the Study Area; therefore, only 12 per cent of the county's population does not reside in the Study Area. Statistics quoted and referenced for the county of Jefferson will be indicative of the characteristics of the Study Area and are, therefore, used extensively throughout this report. All statistics quoted in this section are from the U.S. Census Bureau (U.S. Department of Commerce, 1970), unless otherwise noted. The methods used for making population and economic projections are described in the appendix of this report (Appendix E).

### 1. Population.

#### a. Historic and Projected.

The population of Jefferson County has increased steadily since 1930, and it was projected by the Bureau of Economic Analysis (U.S. Department of Commerce, 1974) that "total population" will increase through the year 2020. Table X-1 illustrates the historic and projected growth for Jefferson County as well as the percentage of change and the projected population of the Study Area.

The population of the Study Area was calculated as being the urban population and a given percentage of the rural population of Jefferson County. Based upon the 1970 population, it is estimated that 64 per cent of the county's rural population reside in the Study Area. This factor was taken as a constant for 1985, 2000 and 2020 based upon the assumption that rural migration patterns would be similar throughout the county.

It is anticipated that the population of Jefferson County will increase and that the proportion of people residing in urban areas will also continue to grow. A statistical breakdown of this phenomenon shows that in 1930, 68 per cent of the county residents lived in rural areas and, in 1970, a mere 29 per cent resided in such areas. As may be expected, this trend towards urbanization is expected to continue and, within the next 50 years, it is projected that 89 per cent of Jefferson County's population will live in urbanized areas. Table X-2 illustrates this trend as it is projected by the U.S. Army Corps of Engineers Vicksburg District.

The geographical distribution of Jefferson County's population shows that the vast majority of residents live south of the Arkansas River. Naturally, the greatest concentration is in the Pine Bluff urban area, but there are numerous small towns scattered throughout the county. According to data prepared by the Southeast Arkansas Regional Planning Commission (1973a), the population distribution in 1970 is delineated in Table X-3.

TABLE X-1

Jefferson County Population
1930 - 2020

| YEAR | JEFFERSON COUNTY POPULATION | PER CENT CHANGE | STUDY AREA | PER CENT OF COUNTY |
|---|---|---|---|---|
| 1930 | 64,154 | - | - | - |
| 1940 | 65,101 | 1.5 | - | - |
| 1950 | 76,075 | 16.9 | - | - |
| 1960 | 81,373 | 7.0 | - | - |
| 1970 | 85,329 | 4.9 | 75,310 | 88.3 |
| 1985 | 102,500 | 20.1 | 95,120 | 92.8 |
| 2000 | 112,200 | 9.5 | 107,340 | 95.7 |
| 2020 | 119,300 | 6.3 | 114,440 | 95.9 |

SOURCE: County Projections: U.S. Department of Commerce, 1974.
Study Area Projections: VTN Louisiana, Inc.

TABLE X-2

Jefferson County Urban Rural Population Balance
1930 - 2020

| YEAR | RURAL | PER CENT | URBAN | PER CENT |
|---|---|---|---|---|
| 1930 | 43,394 | 68 | 20,760 | 32 |
| 1940 | 43,811 | 67 | 21,290 | 33 |
| 1950 | 38,913 | 51 | 37,162 | 49 |
| 1960 | 34,657 | 43 | 46,716 | 57 |
| 1970 | 24,422 | 29 | 60,907 | 71 |
| 1985 | 20,500 | 20 | 82,000 | 80 |
| 2000 | 13,500 | 12 | 98,700 | 88 |
| 2020 | 13,500 | 11 | 105,800 | 89 |

SOURCE: U.S. Department of Commerce, 1970a.
U.S. Army Corps of Engineers, Vicksburg District, pers. comm.

TABLE X-3

Population of Jefferson County by Townships
1970

| TOWN | POPULATION |
|---|---|
| Barrague | 731 |
| Boggy | 604 |
| Bolivar | 389 |
| Dudley Lake | 1,817 |
| Dunnington | 1,360 |
| Jefferson* | 850 |
| Melton | 664 |
| Niven* | 9,202 |
| Old River | 330 |
| Pastoria | 673 |
| Plum Bayou | 2,811 |
| Richland | 1,101 |
| Roberts | 525 |
| Spring* | 1,140 |
| Talledega | 379 |
| Vaugine* | 55,166 |
| Victoria* | 1,005 |
| Villemont | 231 |
| Washington* | 5,443 |
| Whiteville | 908 |
| TOTAL | 85,329 |

* Study Area Townships

SOURCE: Southeast Arkansas Regional Planning Commission, 1973a.

The population density in the Study Area is significantly greater than in either the county or state. In 1970, the statistics revealed that there were 350.8 people per square mile residing in the Study Area while the respective figures for the county and state were 97.7 and 37.0. If the anticipated trend of progressively greater rates of urbanization is realized, the density statistics for both the Study Area and Jefferson County will continue to increase through the year 2020.

b. Migration.

During the decade between 1960 and 1970, Jefferson County experienced a net out-migration of 6,478 people; this number represented 7.8 per cent of the 1960 population (University of Arkansas, 1973). The net migration is calculated by taking the population of a base year 1960, adding the number of births of a given year, and subtracting the number of deaths for the same period. The result is the natural increase or decrease and should be compared to the actual population. Once done, a net migration can be established.

The loss due to migration in Jefferson County was predominantly from the black community. Of the 6,478 people leaving the county, 5,691 were black - 16.2 per cent of the black population.

The loss due to migration in Jefferson County is very high, especially considering that the state experienced a net out-migration of only 2.8 per cent.

c. Mobility Characteristics.

Of the county's population 5 years and older, 53.6 per cent lived in the same house in 1970 as in 1965; 26.6 per cent lived in a different house but in the same county; 7.7 per cent in a different county but in the same state; and 5.9 per cent either abroad or in areas not reported. These figures demonstrate the fact that the population of Jefferson County is more stable than that of the state as a whole. Comparable statistics for the state were: 50.6 per cent were living in the same house they occupied in 1965, 25.5 per cent in the same county, 8.3 per cent in a different county but the same state, 9.9 per cent in another state, and 5.7 per cent had either lived abroad or in areas not reported.

d. Vital Statistics.

In 1970, the fertility rate for women of child-bearing age (15-44) in Jefferson County was significantly higher than comparable state and national statistics. The rates, based on number of births per thousand women of child-bearing age were: 98.8 for Jefferson County, 93.4 for Arkansas, and 87.6 for the United States. These figures relate to a birth rate of 20.3, 18.4 and 18.3, respectively, per thousand population.

The Arkansas Department of Health, Bureau of Vital Statistics (pers. comm.) reports that the death rates (deaths per thousand population) were 10.4 in Jefferson County and 19.7 in the State of Arkansas.

It should be noted that historically, the death rate for the non-white population has been greater than that of whites. Table X-4 illustrates these statistics.

TABLE X-4

Vital Statistics
Jefferson County, Arkansas
1950 - 1970

| | 1950 | 1960 | 1970 |
|---|---|---|---|
| Total Population | 76,075 | 81,373 | 85,329 |
| White | 38,152 | 45,893 | 50,527 |
| Non-White | 37,923 | 35,480 | 34,802 |
| Birth Rate per Thousand Population | 25 | 25 | 20.3 |
| Death Rate per Thousand Population | 9 | 9 | 10 |
| White | 7 | 7 | 10 |
| Non-White | 11 | 11 | 11 |

SOURCE: U.S. Department of Commerce, 1970a.

e. Racial Characteristics.

The 1970 Census of Population indicated that Jefferson County had a racial balance of 50,527 whites and 34,802 non-whites. This equated to 59.2 per cent white and 40.8 per cent non-white. The non-white population was practically all black. The racial distribution in the City of Pine Bluff was similar to that throughout the county - 41.2 per cent non-white compared to the 40.8 per cent county-wide. The historic population shows that the percentage of non-whites has consistently declined since 1930, and it is projected that this trend will continue through the year 2020. Table X-5 illustrates the historic population and racial balance, as well as the projected balance through the next 50 years.

Characteristics of the population by age and sex are given in Table X-6. It should be noted that both historic and projected data are presented for the Pine Bluff Metropolitan Area and that the projected data are based upon "Series E" forecasts made by the Bureau of Economic Analysis (U.S. Department of Commerce, 1974).

f. Households.

In 1970 there were 25,714 occupied housing units in Jefferson County of which 63.9 per cent were owner occupied and 36.1 per cent were renter occupied. Statistics generated by the U.S. Bureau of Census (U.S. Department of Commerce, 1970b) indicate that 46.9 per cent of all occupied units were inhabited by either one or two persons, and that the median number of persons per household was 2.7 and the mean was 3.3 in 1970.

g. Educational Achievement Level.

In 1970 the median school year completed by an Arkansas resident over 25 years of age was 10.5; of this group, 39.9 per cent had completed high school and 6.7 per cent had completed four or more years of college. By contrast, the median school year completed in Jefferson County was 11.1; 43.9 per cent of the population over 25 years of age had completed high school; and 7.6 per cent had four or more years of college. The figures are lower for black residents of Jefferson County. The median school year completed is 8.1, with 21.3 per cent of the blacks having graduated from high school.

These statistics are somewhat lower than those registered on a nationwide basis. Comparable statistics for the United States are: an average of 12.1 years of school completed, 52.3 per cent completing high school and 10.7 per cent completing four or more years of college.

h. Income Characteristics.

In 1969, 23 per cent of the families residing in Jefferson County had incomes that were below the national poverty level; and, in addition to this, 59.7 per cent of the unrelated individuals in the county were also below poverty level. It should be noted that these statistics are greater than comparable state and nation figures. Of the state's population, 22.8 per cent of the families and 58.0 per cent of unrelated individuals were below the poverty level and the national percentages for the same were 10.7 and 37.0, respectively.

TABLE X-5

Jefferson County Racial Characteristics
1930 - 2020

| YEAR | TOTAL | WHITE | PER CENT | NON-WHITE | PER CENT |
|---|---|---|---|---|---|
| 1930 | 64,154 | 27,011 | 42.1% | 37,143 | 57.9% |
| 1940 | 65,101 | 29,079 | 44.7% | 36,022 | 55.3% |
| 1950 | 76,075 | 38,152 | 50.1% | 37,923 | 49.9% |
| 1960 | 81,373 | 45,893 | 56.4% | 35,480 | 43.6% |
| 1970 | 85,329 | 50,527 | 59.2% | 34,802 | 40.8% |
| 1985 | 102,500 | 67,300 | 65.7% | 35,200 | 34.3% |
| 2000 | 112,200 | 77,800 | 69.3% | 34,400 | 30.7% |
| 2020 | 119,300 | 85,900 | 72.0% | 33,400 | 28.0% |

SOURCE: U.S. Department of Commerce, 1970a, 1974.

TABLE X-6

Population by Age and Sex
Jefferson County
1940

| AGE | MALES | PER CENT | FEMALES | PER CENT |
|---|---|---|---|---|
| 0 - 4 | 3,144 | 4.83 | 3,035 | 4.66 |
| 5 - 9 | 3,143 | 4.83 | 3,078 | 4.73 |
| 10-14 | 3,298 | 5.07 | 3,352 | 5.15 |
| 15-19 | 3,242 | 4.98 | 3,270 | 5.02 |
| 20-24 | 2,686 | 4.13 | 3,034 | 4.66 |
| 25-34 | 4,788 | 7.35 | 5,354 | 8.22 |
| 35-44 | 3,854 | 5.92 | 4,464 | 6.86 |
| 45-54 | 3,499 | 5.37 | 3,516 | 5.40 |
| 55-59 | 1,318 | 2.02 | 1,175 | 1.80 |
| 60-64 | 1,060 | 1.63 | 973 | 1.49 |
| 65-74 | 1,553 | 2.39 | 1,319 | 2.03 |
| 75+ | 459 | .71 | 487 | .75 |

SOURCE: U.S. Department of Commerce, 1970a.

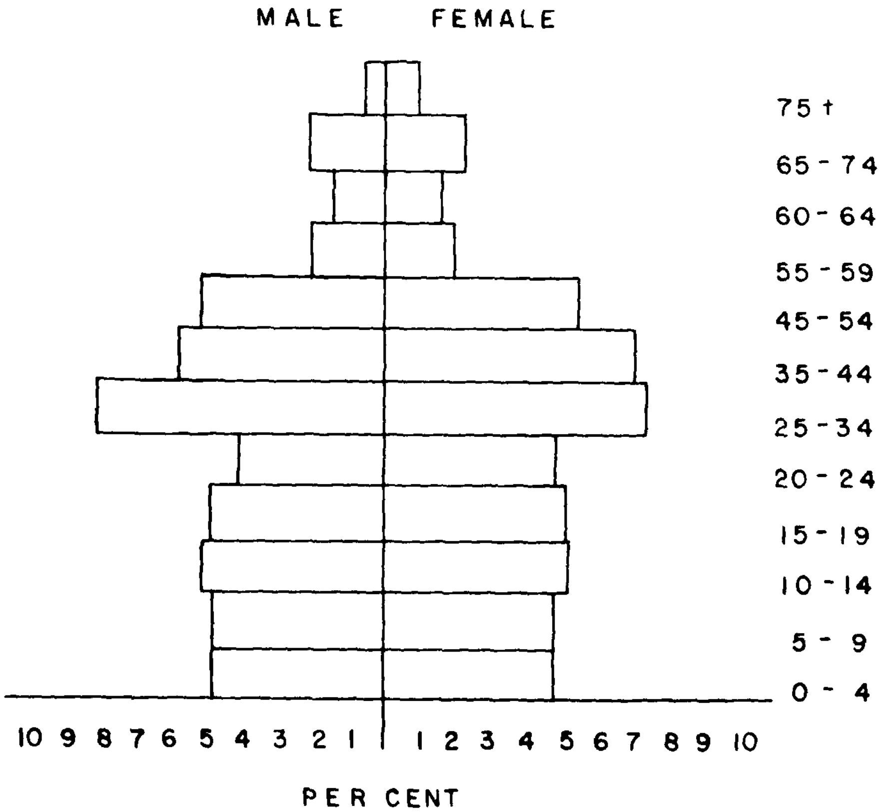


TABLE X-6 (continued)

Population by Age and Sex
Jefferson County
1970

| AGE | MALES | PER CENT | FEMALES | PER CENT |
|---|---|---|---|---|
| 0 - 4 | 3,931 | 4.61 | 3,902 | 4.57 |
| 5 - 9 | 4,540 | 5.32 | 4,457 | 5.22 |
| 10-14 | 4,790 | 5.62 | 4.624 | 5.42 |
| 15-19 | 4,507 | 5.28 | 4,409 | 5.17 |
| 20-24 | 3,307 | 3.88 | 3,706 | 4.34 |
| 25-34 | 4,518 | 5.29 | 4,762 | 5.58 |
| 35-44 | 3,905 | 4.58 | 4,685 | 5.49 |
| 45-54 | 4,235 | 4.96 | 4.535 | 5.31 |
| 55-59 | 1,968 | 2.31 | 2,112 | 2.48 |
| 60-64 | 1,619 | 1.90 | 1,996 | 2.34 |
| 65-74 | 2,393 | 2.80 | 3,059 | 3.58 |
| 75+ | 1,348 | 1.58 | 2,021 | 2.37 |

SOURCE: U.S. Department of Commerce, 1970a.

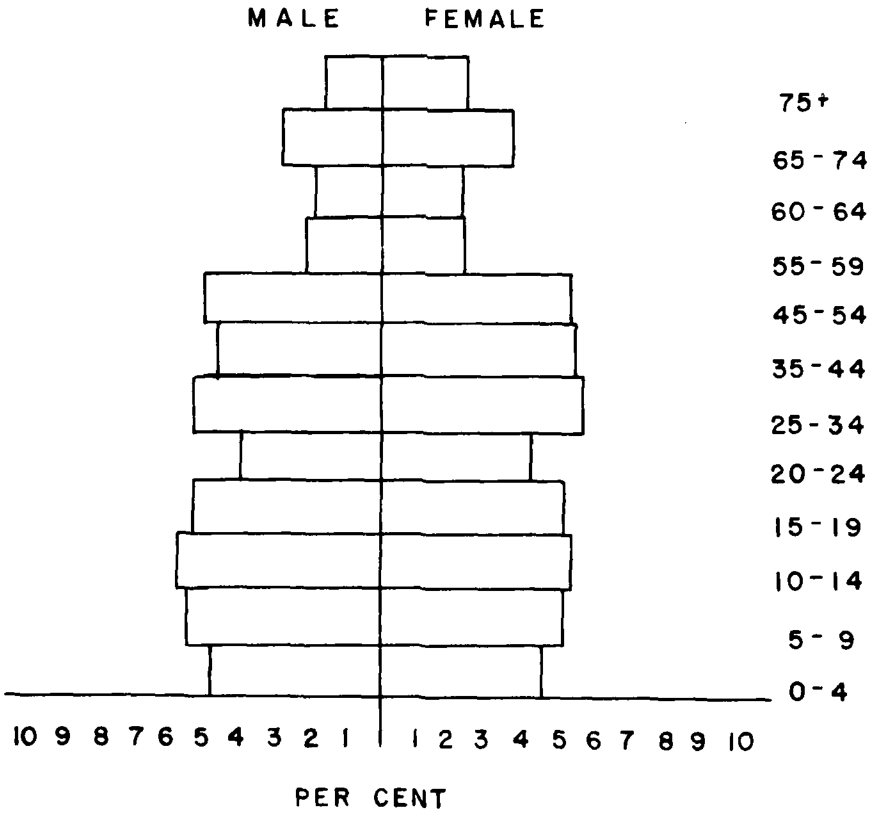
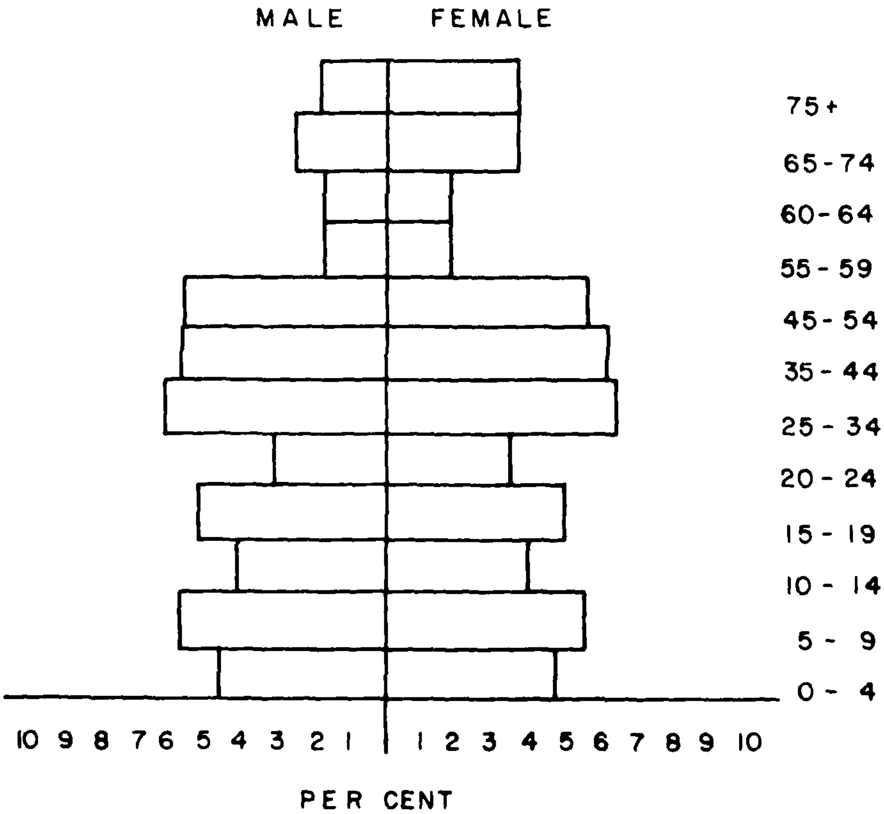


TABLE X-6 (continued)

Population by Age and Sex
Jefferson County
2000

| AGE | MALES | PER CENT | FEMALES | PER CENT |
|---|---|---|---|---|
| 0 - 4 | 5,170 | 4.6 | 5,130 | 4.6 |
| 5 - 9 | 6,230 | 5.5 | 6,110 | 5.4 |
| 10-14 | 4,700 | 4.2 | 4,550 | 4.1 |
| 15-19 | 5,750 | 5.1 | 5,690 | 5.1 |
| 20-24 | 3,440 | 3.1 | 3,980 | 3.5 |
| 25-34 | 6,900 | 6.1 | 7,250 | 6.5 |
| 35-44 | 6,430 | 5.7 | 7,000 | 6.2 |
| 45-54 | 6,290 | 5.6 | 6,400 | 5.7 |
| 55-59 | 1,975 | 1.8 | 2,130 | 1.9 |
| 60-64 | 1,975 | 1.8 | 2,130 | 1.9 |
| 65-74 | 2,860 | 2.5 | 3,990 | 3.6 |
| 75+ | 2,090 | 1.9 | 4,030 | 3.6 |

SOURCE: U.S. Department of Commerce, 1974.



The median income for families in Jefferson County in 1969 was $6,972 compared to $6,273 for Arkansas and $9,590 for the United States. For unrelated individuals comparable statistics were $5,156, $4,950 and $7,699, respectively.

In Jefferson County these statistics represent an 89.9 per cent increase over the 1959 income. In Arkansas and the United States the percentage increases for the same period were 97.0 and 69.4, respectively.

2. Housing.

One of the most significant social problems throughout Jefferson County is the poor quality of housing. Perhaps it is not surprizing when viewed in light of the low median income of area residents that there is an insufficient number of decent, safe and sanitary housing units to meet present needs. The standard housing which does exist is beyond the means of most members of the low income bracket, and, in many instances, these standard units cannot be afforded by families with moderate incomes; as a result, many people have no choice other than to live in dilapidated or deteriorating housing. These statements are supported by the statistics presented in Table X-7, where data is presented for both the State of Arkansas, Jefferson County and the City of Pine Bluff for comparison.

The characteristics of housing are fairly comparable for the state, the county and the city. The most important differences show a better quality of housing, a higher median value and a lower percentage of substandard units in the City of Pine Bluff. Although the statistics quoted in Table X-7 are similar, it is Jefferson County which has the greatest percentage of housing units that are overcrowded and that lack plumbing facilities. The percentage of substandard housing units varies from 20 per cent in the City of Pine Bluff to 25 per cent for the State of Arkansas and to 27 per cent for Jefferson County.

The housing situation for Black residents throughout Jefferson County is significantly different from that enjoyed by other members of the community (Table X-8). Over fifty per cent of the Black occupied housing units in both Jefferson County (55 per cent) and the City of Pine Bluff (58 per cent) were classified as substandard (U.S. Department of Commerce, 1970). The median value of their housing units varied from $5,800 for Jefferson County to $6,400 for the City of Pine Bluff, and the incident of overcrowding and deficient plumbing facilities was also much greater in their homes than in housing in general. These statistics indicate that there is an insufficient number of low cost housing units to meet the needs of this segment of the community.

3. Crime.

Both Pine Bluff and Jefferson County are low crime areas relative to National and State norms. According to statistics compiled by the Federal Bureau of Investigation (1973), the incident of major crimes in Pine Bluff in 1972 was significantly lower than that experienced by the State. Table X-9 illustrates the incident of major crimes per hundred thousand people on local, State and National levels.

The crime profile in the City of Pine Bluff shows that major crimes accounted for approximately 8.5 per cent of all crimes reported in 1972. The most frequent crime during this period proved to be "driving while under the influence of alcohol" which accounted for 55.9 per cent of all crimes reported.

TABLE X-7

*Housing Characteristics*
1970

| CATEGORY | ARKANSAS | JEFFERSON COUNTY | PINE BLUFF |
|---|---|---|---|
| Number of Units | 672,795 | 28,276 | 19,697 |
| Occupied | 91.5% | 91.0% | 92.8% |
| Owner Occupied | 66.7% | 63.7% | 63.1% |
| Renter Occupied | 33.3% | 36.3% | 36.9% |
| Median Value of Owner Occupied Units | $10,000 | $10,800 | $11,400 |
| Median Rent of Renter Occupied Units | $53 | $52 | $54 |
| Median Rooms per Unit | 4.7 | 4.8 | 4.8 |
| Median Number of Persons per Room | less than 1.0 | less than 1.0 | less than 1.0 |
| Median Person per Unit | 3.1 | 2.7 | 2.6 |
| Percentage of Units That Are: | | | |
| Standard | 75% | 73% | 80% |
| Substandard | 25% | 27% | 20% |
| Overcrowded | 10% | 12% | 10% |
| Lacking Some or All Plumbing Facilities | 18% | 19% | 12% |
| Lacking Complete Kitchen Facilities | 13% | 15% | 9% |

SOURCE: U.S. Department of Commerce, 1970b.

TABLE X-8

Characteristics of Housing Units with Black Head of Household
1970

| CATEGORY | ARKANSAS | JEFFERSON COUNTY | PINE BLUFF |
|---|---|---|---|
| Number of Occupied Units | 93,429 | 9,029 | 6,285 |
| Owner Occupied | 52.9% | 55.9% | 57.7% |
| Renter Occupied | 47.1% | 44.1% | 42.3% |
| Median Value of Owner Occupied Units | $5,600 | $5,800 | $6,400 |
| Monthly Median Rent of Renter Occupied Units | $50 | $52 | $54 |
| Median Rooms per Unit | 4.5 | 4.5 | 4.6 |
| Median Persons per Room | less than 1.0 | less than 1.0 | less than 1.0 |
| Median Persons per Unit | 2.8 | 2.6 | 2.6 |
| Percentage of Units That Are: | | | |
| Standard | 42% | 45% | 66% |
| Substandard | 58% | 55% | 44% |
| Overcrowded | 25% | 23% | 21% |
| Lacking Some or All Plumbing Facilities | 48% | 44% | 30% |

SOURCE: U.S. Department of Commerce, 1970b.

TABLE X-9

Number and Incident of Major Crimes
Nation, State, County, City
1972

| CRIME | NATION | | ARKANSAS | | JEFFERSON COUNTY | | PINE BLUFF | |
|---|---|---|---|---|---|---|---|---|
| | NUMBER | RATE PER 100,000 PEOPLE | NUMBER | RATE PER 100,000 PEOPLE | NUMBER | RATE PER 100,000 PEOPLE | NUMBER | RATE PER 100,000 PEOPLE |
| Murder | 18,520 | 8.9 | 204 | 10.5 | 6 | 7.2 | 3 | 5.0 |
| Forcible Rape | 46,430 | 22.3 | 333 | 17.1 | 4 | 4.8 | 1 | 1.7 |
| Robbery | 374,560 | 179.9 | 947 | 48.7 | 16 | 19.2 | 61 | 10.6 |
| Aggravated Assault | 388,650 | 186.6 | 3,197 | 164.5 | 39 | 46.7 | * | * |
| Burglary | 2,345,000 | 1,126.1 | 12,642 | 650.3 | 163 | 195.1 | * | * |
| Larceny $50-Over | 1,837,800 | 882.6 | 11,050 | 568.4 | 131 | 156.8 | 21 | 36.6 |
| Auto Theft | 881,000 | 423.1 | 2,186 | 112.4 | 1 | 1.2 | * | * |

* Statistic Not Available.

SOURCE: Federal Bureau of Investigation, 1973.

According to FBI statistics, the police forces of the city and county were smaller than those of communities of comparable sizes. National statistics show that on the average there are 1.45 policemen per thousand population, while the combined police force of Jefferson County and Pine Bluff represent 1.13 policemen per thousand population.

4. Community Cohesion.

Pine Bluff, founded in 1819, has experienced moderate growth in recent years. Prior to 1940, agricultural and forestry operations accounted for the livelihood of many residents; but since the establishment of the Pine Bluff Arsenal and the subsequent industrial development, their influence on the economy has significantly diminished. With the advent of industry, the composition and profile of Jefferson County's population has changed. Increasingly, the county has become more urbanized since 1940 (from 33 per cent in 1940 to 71 per cent in 1970) and has an increasing percentage of white residents. Since 1940, the non-white population has decreased from 55.3 per cent to 40.8 per cent of the total population of the county and it is likely that this trend will continue.

As the economic base shifts from agricultural to industrial activities, the characteristics of the working population reflect this transition. Industrial employment demands higher skilled workers and offers better wages than commonly found in agricultural activity, and often, this elevates the socioeconomic profile of the community. In Pine Bluff, industry is attracting more and better educated people into the urban areas and, thus, higher standards of community development are necessitated.

During the transition from an agricultural to industrial economy, cultural community characteristics are often altered. In the Pine Bluff area one of the most significant and enduring influences has been that of organized religious groups - especially that of the Baptist Church. With a population of approximately 60,000, the incorporated area offers over 120 churches to meet the needs of the community. Church groups and religious affiliations are integral segments of the Pine Bluff Community and have done much to establish local mores.

Other than organized religious groups, there are no immediately apparent sociological or cultural influences in the Study Area. This situation is quite common among communities that are in the midst of an economic transition; often, economic characteristics become the predominant aspect of community living. In Pine Bluff, the influence of the arsenal, International Paper Company, the Southern Pacific Cotton Belt and the Missouri Pacific Railroads cannot be overlooked when considering primary character of the area. These industries have done much to increase the level of the local economy and have established a sound economic base within the community by contributing to and attracting further industrial development. As industrial operations account for a larger percentage of the area's employment and earnings, social and community characteristics will develop accordingly.

The geographical aspects of the Arkansas River have contributed significantly to the growth and development of the Pine Bluff economy. From the city's very beginnings, the river has been a major source of transportation for agricultural products and trade items; today, the river is being used as a catalyst for industrial development. The increasing activity of the Port of Pine Bluff and the recent expansion of industrial operations in the area are integrally related and

are serving to expand the basic economy of the community. By so doing, the employment level and percentage of individuals and family with incomes below the poverty level is being lowered.

The Arkansas River represents many things to the community of Pine Bluff and could very well be considered a primary focal point of local activity. With the increasing recreational use of the river and the proposed city park, the residents of the Pine Bluff area are maximizing the potentials of the river; the river has become one of the most significant aspects of the community.

The Arkansas River has the potential of solving many of the socioeconomic problems that plague Pine Bluff and Jefferson County. The river and its potential as a transportation corridor is attracting the type of economic development that will make a wider variety of better paying jobs available to residents of this area.

## B. ECONOMIC CHARACTERISTICS.

### 1. The Local Economy.

Prior to the establishment of the Pine Bluff Arsenal in the early 1940's, the economy of Jefferson County was based upon forestry and agricultural activity. Industrial development accompanied the arsenal and continued throughout the 1940's and 1950's; however, industrial growth in the county has been slower than that experienced by the state and especially the nation. On the other hand, the county has experienced significant growth in the non-manufacturing areas of the economy.

The economy of the area is best understood in terms of the county's labor force and its characteristics. Table X-10 is a compilation of pertinent statistics for Jefferson County in 1970. Comparable state and national figures are quoted for a basis for comparison.

It should be noted that the percentage of people employed in industries other than manufacturing and agriculture is higher in Jefferson County than in the state and nation. This is attributed to the large number of people employed in the areas of transportation, utilities, and other service oriented businesses. A more detailed description of the Jefferson County labor force and projections of employment through the year 2020 are presented in Table X-11. The methodology for these projections is described in the appendix of this report (Appendix E).

In forecasting employment and economic growth in the Pine Bluff Metropolitan Area, primary consideration must be given to the impact of the Port of Pine Bluff. The port, which handles such products as fertilizer, steel, liquid chemicals, vermiculite, paper, lumber, rice, grain, machinery, rock, jute, manganese ore, etc., has experienced a thirty per cent increase in tonage handled from 1971 to 1973 (Pine Bluff Port Authority, pers. comm.). The combination of available industrial sites and the wide range of transportation networks in the Pine Bluff area make Jefferson County increasingly attractive to industrial concerns. This statement is supported by the fact that in 1972 and 1973 Pine Bluff experienced twenty-five either new or expanded industrial operations. Such growth will undoubtedly expand the population and economic base in Jefferson County and should help lower the percentage of people unemployed in the area.

TABLE X-10

Labor Force and Employment Status
Jefferson County, Arkansas, United States
1970

| AREA | CIVILIAN LABOR FORCE | PER CENT EMPLOYED IN AGRICULTURE[1] | PER CENT EMPLOYED IN MANUFACTURING | PER CENT EMPLOYED IN OTHER INDUSTRY | % UNEMPLOYED |
|---|---|---|---|---|---|
| Jefferson County | 29,521 | 5.9 | 24.6 | 69.5 | 6.1 |
| Arkansas | 688,630 | 8.4 | 26.1 | 65.5 | 5.7 |
| United States | 80,051,046 | 3.7 | 25.9 | 70.4 | 4.4 |

1 - This category includes employment in agriculture, forestry, and fisheries.

SOURCE: U.S. Department of Commerce, 1970a.

TABLE X-11

Employment by Type and Broad Industrial Sources,
Historical and Projected
Pine Bluff Metropolitan Area, Arkansas

| CATEGORY | 1960 | 1970 | 1985 | 2000 | 2020 |
|---|---|---|---|---|---|
| Total Employment | 25,027 | 27,712 | 37,200 | 43,400 | 46,900 |
| Agriculture* | 2,892 | 1,639 | 1,500 | 1,500 | 1,500 |
| Manufacturing | 5,395 | 6,827 | 9,070 | 11,360 | 12,300 |
| Food & Kindred Products* | - | - | 263 | 182 | 111 |
| Textile Mill Products* | - | - | - | - | - |
| Apparel & Other Products | - | - | 109 | 159 | 197 |
| Lumber Products & Furniture | - | - | 662 | 636 | 566 |
| Paper & Allied Products* | - | - | 4,771 | 5,987 | 6,458 |
| Printing & Publishing | - | - | 272 | 352 | 394 |
| Chemicals & Allied Products* | - | - | 136 | 170 | 197 |
| Primary Metals* | - | - | 127 | 91 | 62 |
| Fabricated Metals & Ordnance | - | - | 390 | 466 | 430 |
| Machinery, Excluding Electrical | - | - | 608 | 920 | 1,132 |
| Electrical Machinery & Supplies | - | - | 1,170 | 1,715 | 2,116 |
| Motor Vehicle & Equipment | - | - | (s) | (s) | (s) |
| Transportation Equipment, Excluding Motor Vehicles | - | - | (s) | (s) | (s) |
| Other Manufacturing | - | - | 499 | 591 | 578 |
| Mining* | 63 | 81 | 130 | 140 | 150 |
| Construction | 1,335 | 1,392 | 2,000 | 2,300 | 2,600 |
| Transportation, Communications, & Public Utilities | 2,538 | 3,119 | 4,500 | 4,800 | 5,200 |
| Trade | 4,711 | 5,245 | 7,200 | 8,300 | 8,900 |
| Finance, Insurance, & Real Estate | 740 | 983 | 1,400 | 1,600 | 1,850 |
| Services | 5,889 | 7,252 | 9,800 | 11,400 | 12,200 |
| Other | 1,464 | 1,174 | 1,600 | 2,000 | 2,200 |

* Major Water Users.

(s) Too Small To Be Projected.

SOURCE: U.S. Department of Commerce, 1970a, 1974.

2. Personal Income.

The U.S. Department of Commerce (1974) has compiled statistical information concerning the historic total personal and per capita income for Jefferson County. Based on past trends and projected employment, forecasts have been made in these areas to the year 2020. This information is presented in Table X-12, along with statistics that relate the per capita income of Jefferson County to that of Arkansas and the United States. It is interesting to note that per capita income in Jefferson County is approximately the same as the state level, but yet, significantly below the national average.

It should be noted that all dollar statistics quoted in this section will be based upon the value of the "1967 dollar." To convert 1967 dollars to 1973 dollars, the 1967 dollar can be multiplied by 1.30.

The median family income and percentage of families below the poverty level and comparable statistics for unrelated individuals are illustrated in Table X-13. This table also includes both state and national figures and is intended to be a basis for comparison in analyzing the earnings of Jefferson County residents.

Table X-13 illustrates the fact that an extraordinary number of Arkansas residents have incomes below that of the poverty level. On the average, Jefferson County families enjoy greater income than their counterparts on the state level, but unrelated individuals residing in the county have a significantly lower income than that on a statewide basis.

In studying the income earned by Jefferson County residents, it is essential to understand which industries account for the monies earned in the local economy. Table X-14 is a percentage breakdown of earnings by broad industrial sources. It should be noted that since 1950 the earnings in agriculture have decreased significantly while manufacturing has greatly increased. Based on historic trends and projected employment, the Bureau of Economic Analysis has made forecasts to the year 2020. These predictions are also included in Table X-14 (U.S. Department of Commerce, 1974). As supplementary information, the industries that are major water users are delineated.

The manufacturing industries in Jefferson County continue to play an increasingly significant role in the area's economy. As they expand, the service sector (those businesses catering to these industries and their employees) prospers. Table X-15 indicates the value added by manufacturing in Jefferson County since 1947 and projects this growth rate to the year 2020.

Additional information concerning the major industries in Jefferson County, their employment, and date of establishment are appended (Appendix C, Table C-68).

A significant indicator of the vitality of the service sector of the economy is the level of wholesale and retail trade activity. Table X-16 contains this information.

3. Bank Deposits.

The amount of money deposited in local banking institutions is an indicator of the strength of the local economy. According to figures compiled by the Bureau

TABLE X-12

Total Personal Income and Per Capita Income
Pine Bluff Metropolitan Area - Jefferson County
1929 - 2020

| YEAR | TOTAL PERSONAL INCOME | P.C.I. DOLLARS | P.C.I. % OF STATE | P.C.I. % OF U.S. |
|---|---|---|---|---|
| 1929 | $ 56,057,000 | $ 875 | 59 | 53 |
| 1950 | 87,270,000 | 1,148 | 101 | 56 |
| 1959 | 130,512,000 | 1,632 | 105 | 67 |
| 1970 | 226,934,000 | 2,656 | 105 | 76 |
| 1985 | 423,000,000 | 4,100 | 102 | 76 |
| 2000 | 724,100,000 | 6,400 | 100 | 79 |
| 2020 | $ 1,309,800,000 | $10,900 | 99 | 83 |

Note: All dollars are 1967 dollars.

SOURCE: U.S. Department of Commerce, 1974.

TABLE X-13

Median Income and Poverty Level
Jefferson County, Arkansas, United States
1969

| AREA | FAMILIES MEDIAN INCOME | FAMILIES PERCENTAGE BELOW POVERTY LEVEL | UNRELATED INDIVIDUALS MEDIAN INCOME | UNRELATED INDIVIDUALS PERCENTAGE BELOW POVERTY LEVEL |
|---|---|---|---|---|
| Jefferson County | $6,972 | 23.0 | $1,326 | 59.7 |
| Arkansas | $6,273 | 22.8 | $1,547 | 58.0 |
| United States | $9,590 | 10.7 | $2,489 | 37.0 |

Note: Dollars in this table are not 1967 dollars. These figures represent actual income.

SOURCE: U.S. Department of Commerce, 1970a.

TABLE X-14

Earnings by Type and Broad Industrial Sources
Major Water Users Indicated
Pine Bluff Metropolitan Area - Jefferson County
(Percentages)

| CATEGORY | 1950 | 1960 | 1970 | 1985 | 2000 | 2020 |
|---|---|---|---|---|---|---|
| Total Earnings | 100 | 100 | 100 | 100 | 100 | 100 |
| Agriculture, Forestry & Fisheries* | 18 | 15 | 12 | 8 | 5 | 4 |
| Mining* | (D) | (D) | 0 | (S) | (S) | (S) |
| Contract Construction | 7 | 5 | 4 | 5 | 5 | 4 |
| Manufacturing | 13 | 23 | 23 | 26 | 28 | 28 |
| Food & Kindred Products* | 3 | 2 | 2 | 1 | 0 | 0 |
| Textile Mill Products* | (D) | (D) | (D) | (D) | (D) | (D) |
| Apparel & Other Fabric Products | (D) | (D) | (D) | (D) | (D) | (D) |
| Lumber Products & Furniture | 4 | 3 | 2 | 2 | 2 | 1 |
| Paper & Allied Products* | 1 | 10 | 11 | 12 | 12 | 12 |
| Printing & Publishing | 1 | 1 | 1 | 1 | 1 | 1 |
| Chemical & Allied Products* | (D) | (D) | 0 | 0 | 0 | 0 |
| Primary Metals* | (D) | (D) | (D) | (D) | (D) | (D) |
| Fabricated Metals & Ordnance | (D) | (D) | (D) | (D) | (D) | (D) |
| Machinery, excluding Electrical | (D) | (D) | (D) | (D) | (D) | (D) |
| Electrical Machinery & Supplies | (D) | (D) | (D) | (D) | (D) | (D) |
| Motor Vehicles & Equipment | - | - | 0 | (S) | (S) | (S) |
| Transportation Equipment, Excluding Motor Vehicles | - | - | 0 | (S) | (S) | (S) |
| Other Manufacturing | 1 | 4 | 2 | 2 | 2 | 2 |
| Transportation, Communications, & Public Utilities | 18 | 12 | 13 | 11 | 9 | 8 |
| Wholesale & Retail Trade | 16 | 16 | 14 | 15 | 14 | 14 |
| Finance, Insurance, & Real Estate | 3 | (D) | 3 | 4 | 4 | 4 |
| Services | 10 | 12 | 13 | 14 | 16 | 17 |
| Government | 15 | 13 | 18 | 17 | 19 | 21 |

* Major water users.

S = insignificant

D = disclosure problems

SOURCE: U.S. Department of Commerce, 1970a, 1974.

TABLE X-15

Value Added by Manufacturing
Pine Bluff Metropolitan Area - Jefferson County
1947 - 2020
(Thousands of 1967 Dollars)

| YEAR | AMOUNT |
|---|---|
| 1947 | $ 12,432 |
| 1954 | 17,922 |
| 1958 | 32,379 |
| 1963 | 78,828 |
| 1967 | 92,400 |
| 1985 | 165,999 |
| 2000 | 231,737 |
| 2020 | $319,389 |

SOURCE: U.S. Army Corps of Engineers, Vicksburg District, pers. comm.

TABLE X-16

Retail and Wholesale Trade
Pine Bluff Metropolitan Area - Jefferson County
1948 - 2020

| YEAR | RETAIL TRADE | WHOLESALE TRADE |
|---|---|---|
| 1948 | $ 53,764,000 | $ 45,103,000 |
| 1954 | 67,764,000 | N/A |
| 1958 | 73,663,000 | 87,229,000 |
| 1963 | 93,640,000 | 101,146,000 |
| 1967 | 113,877,000 | 137,434,000 |
| 1985 | 163,779,000 | 208,524,000 |
| 2000 | 210,022,000 | 274,337,000 |
| 2020 | 271,680,000 | 362,088,000 |

Note: All dollar amounts are based on "1967 dollars".

SOURCE: U.S. Army Corps of Engineers, Vickburg District, pers. comm.

of Economic Analysis (U.S. Department of Commerce, 1974), deposits in Jefferson County have risen from $51,214,000 in 1949 to $109,842,000 in 1970. On a per capita basis, this equates to approximately $673.21 in 1950 and in increase to $1,287.28 in 1970. Projecting the per capita deposit through the year 2020 yields: $1,495.06 in 1985; $1,744.90 in 2000; and $2,116.43 in 2020. Table X-17 is a compilation of historic and projected bank deposits for Jefferson County.

## C. AGRICULTURAL ACTIVITY.

Agriculture in the Pine Bluff Metropolitan Area (Jefferson County) has been on the decline relative to the growth of other facets of the Jefferson County economy. As shown in Table X-14, in 1950 agriculture accounted for 18 per cent of the county's total earnings, but it has been on the decline since and is expected to diminish to a mere four per cent of the county's total earnings by the year 2020. A specific breakdown of the products sold and their historic and projected values are illustrated in Table X-18.

A significant trend in Jefferson County's agricultural activity is that while the total number of farms is decreasing, the size and value of those remaining are increasing. This phenomenon is quite common on both a state and national level, and merely represents the growing interest of large commercial farms in agriculture. Table X-19 depicts this trend in Jeffe.son County by exhibiting the number of farms, their average size and value over the thirty year period between 1940 and 1969. During this same period, the total acreage of cropland in Jefferson County has increased from 213,751 to 231,441, and the harvest cropland has increased from 175,201 acres to 204,350 acres. These statistics, along with compatible data for irrigated cropland, are illustrated in Table X-20.

According to statistics assembled by the U.S. Department of Commerce (1972), the major crops in Jefferson County are soybeans, cotton, rice and wheat. Table X-21 illustrates the number of acres harvested and their average yield for 1969 and 1972. These statistics demonstrate the importance of soybean and cotton production in Jefferson County.

## D. TRANSPORTATION CORRIDORS.

The Pine Bluff Metropolitan Area has excellent railroad and water based transportation systems, but is deficient in major highway networks. This situation exists because of the lack of interstate highways in Jefferson County and the extensive amount of at-grade railroad crossings in the urbanized area of Pine Bluff. A categorical listing of the transportation facilities and networks in the area follows.

### 1. Highways.

In the Pine Bluff Metropolitan Area, there are over 500 miles of existing streets and highways. Of these, 54 miles are major arterials and 40 miles are classified as collectors. The most serious deficiency in the highway network is the right-of-way widths on major streets. Approximately 75 per cent of the roads in the Study Area are sufficient for only two lanes of moving traffic (Arkansas State Highway Department, 1969). The major highways in the Study Area are:

TABLE X-17

Bank Deposits
Pine Bluff Metropolitan Area - Jefferson County
1949 - 2020

| YEAR | AMOUNT |
|---|---|
| 1949 | $ 51,214,000 |
| 1956 | 70,262,000 |
| 1964 | 95,260,000 |
| 1970 | 109,842,000 |
| 1985 | 153,244,000 |
| 2000 | 195,778,000 |
| 2020 | 252,490,000 |

Note: All dollars are "1967 dollars".

SOURCE: U.S. Army Corps of Engineers, Vicksburg District, pers. comm.

TABLE X-18

Value of Farm Products Sold
Pine Bluff Metropolitan Area
1940 - 2020
(Thousands of 1967 Dollars)

| YEAR | CROPS | LIVESTOCK & PRODUCTS | OTHER | TOTAL |
|---|---|---|---|---|
| 1940 | 10,079 | 1,036 | 58 | 11,173 |
| 1945 | 10,169 | 1,016 | 40 | 11,225 |
| 1950 | 12,251 | 781 | 25 | 13,057 |
| 1954 | 16,776 | 770 | 27 | 17,573 |
| 1959 | 20,562 | 1,186 | 79 | 21,827 |
| 1964 | 23,193 | 1,120 | 50 | 24,363 |
| 1969 | 15,320 | 2,071 | 54 | 17,445 |
| 1985 | - | - | - | 28,051 |
| 2000 | - | - | - | 33,480 |
| 2020 | - | - | - | 40,718 |

SOURCE: U.S. Department of Commerce, 1972, 1974.

TABLE X-19

Size and Value of Farms
Pine Bluff Metropolitan Area
1940 - 1969
(Thousands of 1967 Dollars)

| YEAR | NUMBER OF FARMS | AVERAGE SIZE OF FARMS (ACRES) | VALUE OF LAND & BUILDINGS AVERAGE PER FARM | VALUE OF LAND & BUILDINGS AVERAGE PER ACRE |
|---|---|---|---|---|
| 1940 | 6,484 | 49 | 5,650 | 115.31 |
| 1945 | 5,900 | 55 | 3,886 | 70.82 |
| 1950 | 5,079 | 67 | 5,690 | 84.92 |
| 1954 | 3,660 | 94 | 8,807 | 93.69 |
| 1959 | 1,745 | 179 | 22,067 | 123.28 |
| 1964 | 958 | 316 | 84,558 | 267.59 |
| 1969 | 780 | 372 | 118,314 | 318.05 |

SOURCE: U.S. Department of Commerce, 1972.

TABLE X-20

Cropland
Pine Bluff Metropolitan Area
1940 - 1969

| YEAR | ACRES | | |
|---|---|---|---|
| | TOTAL CROPLAND | CROPLAND HARVESTED | CROPLAND IRRIGATED |
| 1940 | 213,751 | 175,201 | N/A |
| 1945 | 208,185 | 169,202 | N/A |
| 1950 | 221,035 | 178,559 | 8,641 |
| 1954 | 213,559 | 171,871 | 35,969 |
| 1959 | 193,457 | 158,642 | 38,300 |
| 1964 | 206,515 | 177,315 | 39,706 |
| 1969 | 231,441 | 204,350 | 30,039 |

SOURCE: U.S. Department of Commerce, 1972.

TABLE X-21

Major Crops
Jefferson County, Arkansas

| CROP | 1969 | | 1972 | |
|---|---|---|---|---|
| | ACRES HARVESTED | AVERAGE YIELD/ACRE | ACRES HARVESTED | AVERAGE YIELD/ACRE |
| Soybeans | 122,200 | 20.0 Bushels | 109,000 | 20.0 Bushels |
| Cotton | 58,800 | 668 Pounds | 91,900 | 637 Pounds |
| Rice | 21,300 | 43.7 Cwt. | 17,880 | 480.0 Cwt. |
| Wheat | 3,760 | 26.2 Bushels | 3,100 | 30.0 Bushels |

SOURCE: U.S. Department of Commerce, 1972.

+ U.S. Highway 65 - The primary route to Little Rock and Interstates 30 and 40.

+ U.S. Highway 79 - Direct route to Memphis, Tennessee and the smaller cities of Camden and El Dorado, Arkansas to the southwest.

+ U.S. Highway 270 - Provides Jefferson County with access to the Ouachita Mountain Range and Interstate Highway 30.

+ Arkansas State Highway 15 - Running north-south through Pine Bluff, this highway serves the downtown area and converges into U.S. Highway 79.

2. Waterborne Transportation (see also Plate X-1).

Waterborne commerce is handled through the Port of Pine Bluff - the only slack water port on the Arkansas River. Opened in 1970, this 3.5 million dollar facility is currently handling greater tonage than estimated for the year 1980. The port offers a 1,600 foot wharf with rail service, a 40,000 square foot in-transit warehouse, bulk liquid storage, grain loading and unloading facilities, and heavy duty cranes to accommodate cargo transfers. Channel maintenance and service for the port and river are provided by the U.S. Army Corps of Engineers.

3. Rail Service.

The Pine Bluff Metropolitan Area is served by the Southern Pacific-Cotton Belt and the Missouri Pacific railroads. Both of these lines have local switch engines, grant reciprocal switching and offer piggyback service. Each line offers a full range of services to the area and they maintain both rate and traffic offices in Pine Bluff. In addition to this, the Cotton Belt has division offices, engineers offices, diesel and car repair shops, and an electronic gravity yard in Pine Bluff.

4. Air Transportation.

Grider Field, the Pine Bluff Municipal Airport, has a 5,100-foot lighted asphalt runway and a 2,000-foot sod runway. The airport is serviced by a commuter carrier (Astro Airways) operating between Pine Bluff and Memphis. There are also several fixed based operators offering charter and cargo service. The airport has an FAA flight service station (days only), a control tower (operating between 7 a.m. and 8 p.m.), and a VORTAC instrument approach system.

5. Highway Transit System.

Pine Bluff is served by 12 common carrier truck lines (eight of which maintain terminals in the area) and three major bus lines that provide both intra- and interstate service.

Public transit within Pine Bluff is currently being subsidized by the city because of the lack of operating revenues. This service is severely limited and must be improved if it is to meet the needs of the community.

Plate X-1 The Port of Pine Bluff at Lake Langhofer [slackwater harbor]

A composite map depicting the transportation system in the Pine Bluff Metropolitan Area is illustrated in Figure X-1.

## E. RELATIONSHIP OF SOCIOECONOMIC CHARACTERISTICS TO THE ENVIRONMENT OF THE STUDY AREA.

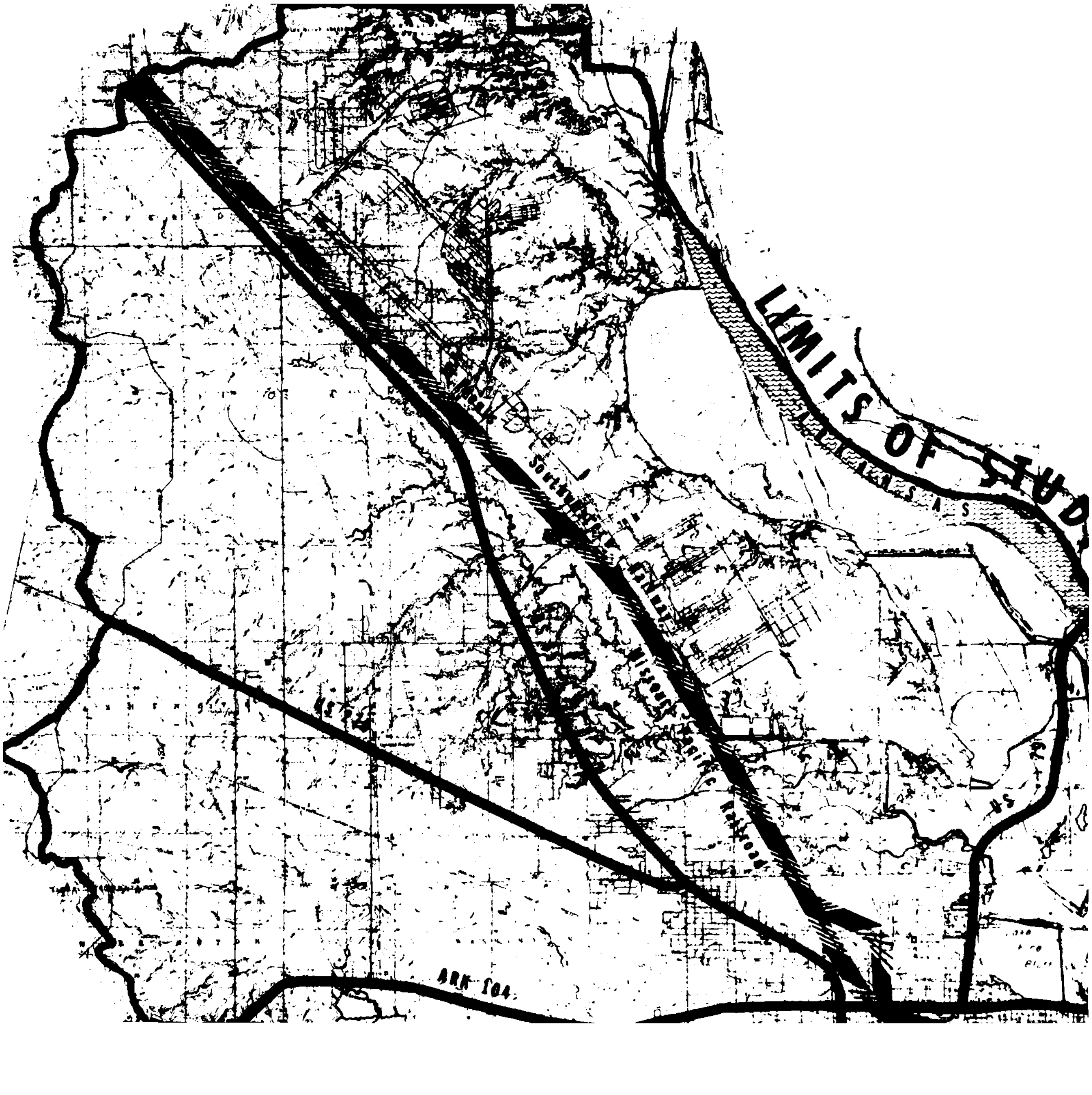
The geographical and environmental features of an area are the primary influences of social and economic characteristics of its population. The geography of a given area determines the initial physical development patterns of a new community and often establishes the parameters for economic development. However, as an area develops, the economy and social characteristics begin to influence the physical and biological environment. The history of Pine Bluff indicates that it is an example of this phenomena.

In the early 1800's, Pine Bluff was settled because its high elevation offered protection from the floodwaters of the Arkansas River. The surrounding area provided early settlers land for agricultural usage and logging operations, as well as a river for the efficient transportation of their goods.

The most significant physiographic characteristics of the Pine Bluff area are the Quaternary Terrace and Alluvial Plain (see Section II). A natural divide runs in a northeasterly direction, separating these predominant physiographic features. The Quaternary Terrace has been the area of forestry operations and the Alluvial Plain has been in agricultural usage since the early settlement of the city. Prior to the 1940's, these activities were the mainstays of the local economy and fashioned the social structure of the growing community. With the establishment of the Pine Bluff Arsenal in the 1940's, the area began to industrialize. The institution of large industrial concerns altered the local economy, and reduced the community's dependence upon the land for their economic well being.

The urbanization of the Pine Bluff area, in response to industrialization, brought new impacts to the area's natural environment; impacts which are still prevalent today. Problems associated with urban runoff, municipal and industrial wastes, and the infringement of residential and industrial areas upon productive natural areas are some of the contemporary impacts having a detrimental effect on the environmental quality of the Study Area. Narrative descriptions of these and other problems are presented in sections II, III, IV, V and VI.

In summary, the general socioeconomic characteristics of the residential population of Pine Bluff were directly related to the physical and natural environment of the area until the community began to industrialize. The advent of industry has lessened dependence upon the land and has created more subtle relationships between the community and the area's environment. The relationship today is more of a "concern" than a "dependence" as it has been in years past.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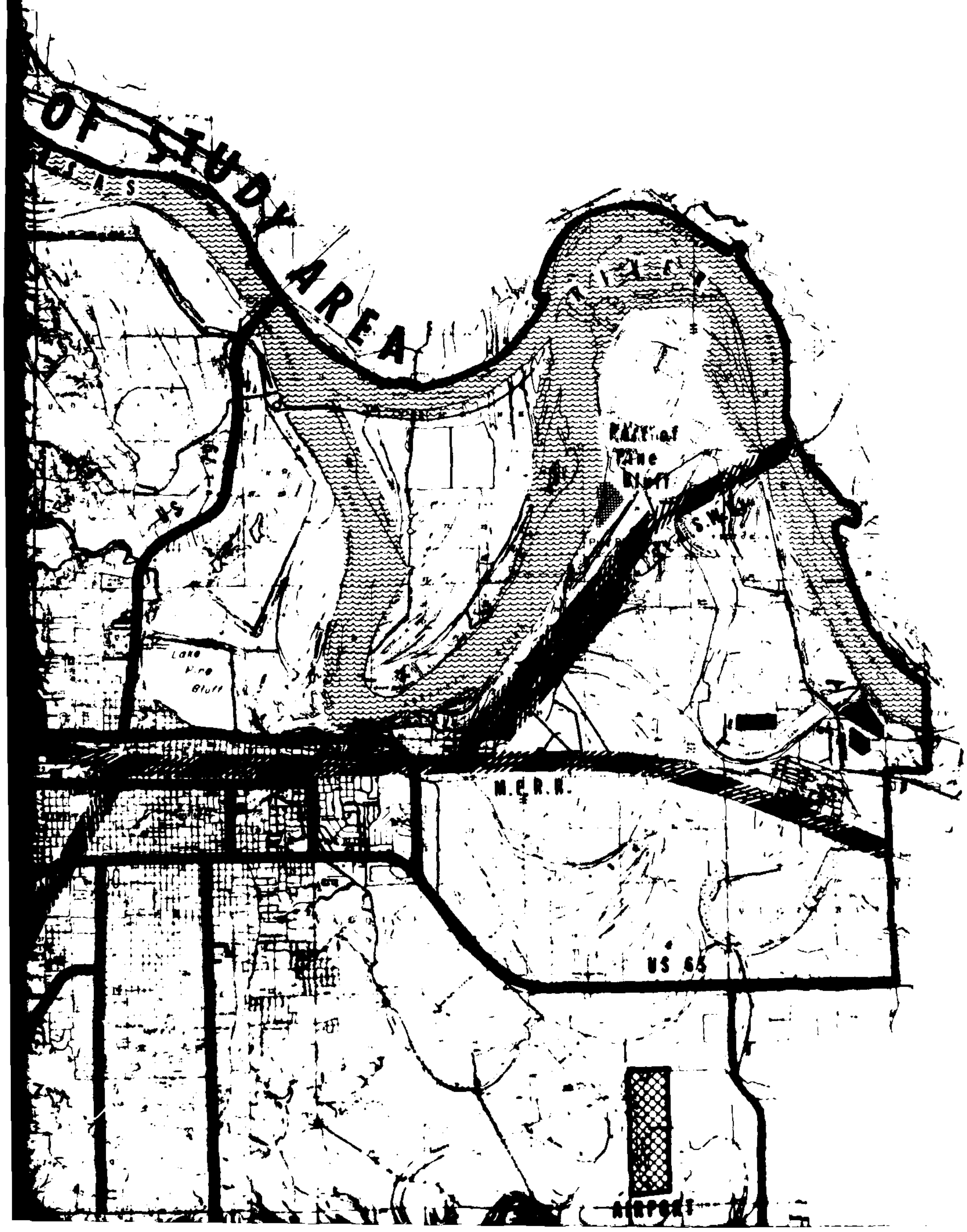
Missouri Pacific Railroad
ARK 104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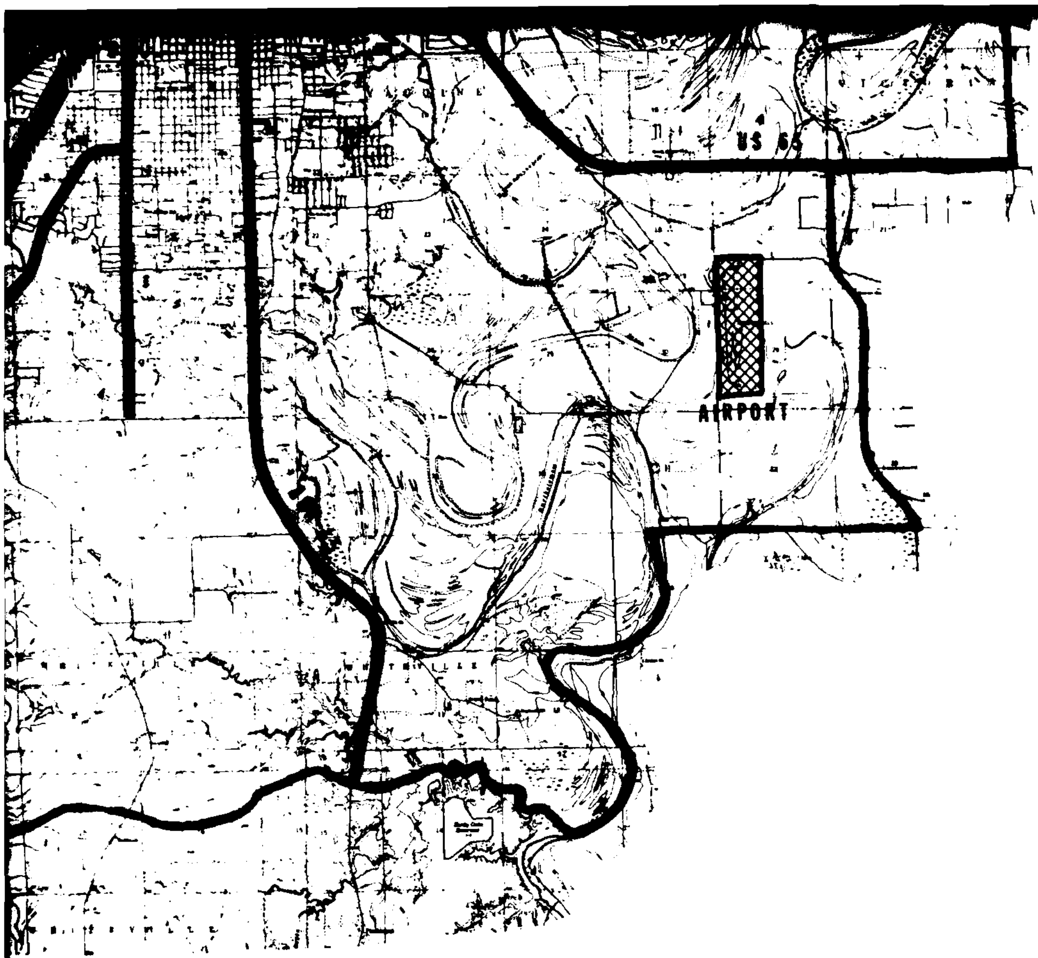


CORRIDORS
STUDY AREA

FIG. X-1

# Public Meeting Scheduled On Environmental Study

By JAMES R. TAYLOR
Of The Commercial Staff

A public meeting will be held at 7 p.m. Thursday to inform the public about an environmental inventory and analysis being conducted here in connection with the Pine Bluff Urban Water Management Study.

The meeting, which will be cosponsored by the Army Engineers and the Citizens Advisory Committee on the study, will be held in the Simmons Room of the Simmons First National Bank at 501 Main Street.

The Engineers, who are conductin

such agencies as the Southeast Arkansas Regional Planning Commission, the Southeast Arkansas Economic Development District and the United States Geological Survey.

According to the VTN Engineer contract, "This study will provide sufficient background information to be utilized as a primary step in understanding the environmental conditions in the general study area."

The information to be compiled in the environmental assessment, the contract states, will be used in "developing alternatives for water ...ter study, resources development

resources, aesthetic resources and environmental use and management areas, existing land use, ground and surface water quality, air and noise pollution and socioeconomic background.

In the second phase, the contract states, VTN will analyze the relationships between the environment; evaluate the various aspects of the environment; evaluate the relative importance of the study area's environmental resources; present a list of land, water and wetland areas and other environmental features that warrant consider... preserv...

# PUBLIC PARTICIPATION XI

# XI
# PUBLIC PARTICIPATION

As success of the Pine Bluff Metropolitan Area Urban Water Management Study depended heavily on effective and meaningful public participation, every effort was made to keep the public informed as the study progressed. The major vehicles for public involvement included: 1) the Citizens Advisory Committee, initiated by the Southeast Arkansas Regional Planning Commission; 2) a quarterly newsletter published by the Corps of Engineers, Vicksburg District; and 3) a series of public informational meetings.

Meetings with representatives of the Citizens Advisory Committee transpired in VTN's Pine Bluff Office on February 11, 15 and 23, 1974. On February 25, 1974, an organizational meeting was cosponsored by the Citizens Advisory Committee, VTN, and the Vicksburg District, Corps of Engineers and held at VTN's Pine Bluff Office. Over 40 Pine Bluff area residents attended. The purpose of the meeting was to mobilize the Pine Bluff citizenry for participation on the Citizens Advisory Committee. The agenda included introductory statements by the chairperson of the Citizens Advisory Committee, representatives of the Corps of Engineers, and VTN. A notice for the Public Meeting of March 21, 1974, was distributed (Appendix E) as were cards asking for personal information and areas of interest. Each member was asked to check any particular area of interest in which he could offer any input. The meeting's highlights were carried in the Pine Bluff Commercial on February 26, 1974.

The Pine Bluff Urban Water Management Study was presented on March 21, 1974. The presentations by Mrs. Jane Stern, Citizens Advisory Committee; Mr. Jesse McDonald, Corps of Engineers; Dr. Robert Irving, VTN; and Mr. J. Southall, Arkansas Department of Pollution and Ecology were well received by the 92 citizens in attendance. The meeting terminated a considerable amount of effort and coordination among many individuals. Radio and newspaper coverage before and after the Public Meeting served to clarify the goals of the Environmental Assessment Phase for the Pine Bluff public (Appendix E).

Within the latter stages of the study, public environmental questionnaires and surveys were conducted (Section VIII.C.); these were coordinated and analysed in part by the Citizens Advisory Committee.

Throughout the course of this study, VTN contacted and coordinated closely with many individuals and with a wide variety of organizations.

Persons who played a major role in this contact and coordination include:

- Mrs. Jane Stern, Chairperson for the Citizens Advisory Committee and Mrs. Marie Locke. Both ladies made inestimable contributions to the study, particularly in the generation of the bird list and vascular plant list, respectively.

- All members of the Citizens Advisory Committee made numerous contributions to the study.

- Mr. John Hogue, biologist for the Arkansas Department of Fish and Game, conducted the rotenone programs for sampling the fish communities.

- Mr. Arthur Holmes, Mr. Dennis Vogt and all members of the Pine Bluff Regional Planning Commission, provided innumerable data and support.

- Mr. Vaughn Black, director of the Parks and Recreation Department provided the nucleus for chapters on esthetics and recreation.

- Mr. Andrew Crossett of the Soil Conservation Service provided valuable soils data and information for many other facets of the study.

- Mr. T. E. Neeley, Pine Bluff coonhunter and businessman sacrificed many nights in search of raccoons to be used in the heavy metals and pesticides testing.

Other contributors to the study include: Mr. H. V. Gill and Mr. Carl McGrew, U. S. Soil Conservation Service; Dr. Han Tai, U. S. Pesticide Monitoring Laboratory, Bay St. Louis, Mississippi; Dr. Tim Matzke, E. P. A. Region VI; Mr. H. Halberg, U. S. Geological Survey; Mr. Ken Manuel, Mr. J. Click, Sr. and Mr. John T. Watts, Pine Bluff Arsenal; Dr. Ken Beadle, Arkansas State University, State University; Mr. T. Fudge, Jefferson County Agent; Dr. E. B. Smith, University of Arkansas, Fayetteville; Mr. Norman Williams, Arkansas Geologic Commission; Dr. M. S. Bhangoo, University of Arkansas, Pine Bluff Soils Laboratory; Mr. Bill Bauknight and others, University of Arkansas, Pine Bluff; Mr. Murray Reichen, General Waterworks Corporation; Mr. T. J. Rowell, City Engineer, Pine Bluff; Mr. Philip Klopfenstein and the Jefferson County Historical Commission; and Mr. John Pitts, Pine Bluff Street Department.

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# XII
# BIBLIOGRAPHY

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# GLOSSARY

# XIII
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AFFLUENT - A tributary stream having an abundant flow.

ALGAL BLOOM - Rapid and flourishing growth of algae.

ALLUVIAL - Of/alluvium (q.v.)

ALLUVIUM - Sediments, usually mineral or inorganic, deposited by running water.

AMBIENT - Surrounding on all sides.

ANAEROBIC - Condition characterized by absence of air or free oxygen.

AUTHIGENIC - Minerals which have not been transported but which have been formed in situ.

AVAILABLE WATER CAPACITY (ALSO TERMED AVAILABLE MOISTURE CAPACITY) - The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

BENTHIC - Of/ the bottom of lakes or oceans. Of/ organisms which live on the bottom of water bodies.

BENTHOS - Those organisms which live on the bottom of a body of water.

BIG GAME - Large animals especially mammals pursued or taken in hunting.

BIOLOGICAL DIVERSITY - The number of kinds of organisms per unit area or volume; the richness of species in a given area.

BIOCHEMICAL OXYGEN DEMAND - The amount of dissolved oxygen used by micro-organisms in the biochemical oxidation of organic matter.

B.P. - Before present.

CHEMICAL OXYGEN DEMAND - The amount of dissolved oxygen equivalent to the organic mater in a sample that is susceptible to oxidation by a strong chemical oxidant.

COEFFICIENT OF STORAGE - The coefficient of storage (S) is the volume of water an aquifer releases or takes into storage per unit surface area (usually per square foot) of the aquifer per unit change in the component of heat (usually one foot).

DECIBEL - A tenth of a bel (the logarithm of a ratio of two values of power).

DECIBELS "A" WEIGHTED - Sound pressure level adjusted to human hearing on a sound level meter.

EDAPHIC - Of/ the influence of the soil especially on the plants growing upon it.

ENDANGERED SPECIES - Species that are in danger of becoming extinct.

ENDEMIC - Indigenous or native in a restricted locality; confined naturally to a certain limited area or region.

EPIBENTHOS - Life forms attached to and growing upon rather than within the bottoms of standing and flowing waters.

EPIPHYTES - Plants which grow on other plants but which are not parasitic.

EPOCH - A subdivision of a period; a term applied primarily to a major subdivision, but is likewise used for any subordinate unit except for the subdivisions of the Pleistocene epoch.

FISH KILL - Pertaining to sudden death of fish population.

FISSILE - A property of splitting easily along closely spaced parallel planes.

FLOOD PLAIN - That portion of a river valley which is covered in periods of high (flood) water; ordinarily populated by organisms not greatly harmed by short immersion.

PLUVIAL - Of or pertaining to rivers; growing or living in streams or ponds; produced by river action.

FRAGIPAN - A loamy, brittle, subsurface horizon that is very low in organic matter and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 15 to 40 inches (38.1-101.6 cm) below the surface.

GAME - Wild animals usually mammals or birds hunted for sport or food and subject to legal regulations.

GEOMORPHOLOGY - The study of topographical features of the earth, and of the means by which, and the manner in which they have been produced.

GLACIAL AGE - Of, or relating to, or being any of those parts of geologic time from Precambrian onward when a much larger portion of earth was covered by glaciers than at present.

GLAUCONITE - A green mineral, closely related to micas and essentially a hydrous potassium iron silicate.

GREENBELT - A plot of vegetated land separating or surrounding areas of intensive residential or industrial use and devoted to recreation or park uses.

GROUND WATER - Water found underground in porous rock or soil strata.

HABITAT - The environment, usually the natural environment, in which a population of plants or animals occurs.

HERBACEOUS - Of/ any plant lacking woody tissue in which the leaves and stem fall to ground level during freezing or drying weather.

HERPETOFAUNA - The amphibian and reptile species characteristic of an area.

HYDROGRAPH - A graph showing, for a given point on a stream or for a given point in any drainage system, the discharge, stage, velocity, or other property of water with respect to time.

ISOCHLOR - A line on a map connecting points having the same chloride concentration at the same time.

ISOHALINE - A line which connects points having the same salt concentration at the same time.

ISOHYET - A line which connects points having equal or constant values of a given quantity, such as rainfall or precipitation with respect to time or space.

LAKE - A large body of water contained in a depression of the earth's surface and supplied from drainage of a larger area. Locally may be called a pond.

LARVA - Early developmental stage of an animal which changes structurally when it becomes an adult (e.g., tadpole, caterpillar).

LENTIC - Of/ still or slowly flowing water situations (e.g., lakes, ponds, swamps).

LIMNOLOGY - The study of the biological, chemical and physical features of inland waters.

LOTIC - Of/ rapid water situations, living in waves or currents.

MARSH - Low-lying soft, wet land, commonly covered (sometimes seasonally) entirely or partially with water and characterized by grasses.

MOTTLING, SOIL - Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance--few, common, and many, size--fine, medium and coarse; and contrast--faint, distinct, and prominent. The size measurements are these: fine, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; medium, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and coarse, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

NURSERY - An area where animals congregate for giving birth or where the early life history stages develop.

NUTRIENTS - Chemical elements essential to life. Macronutrients are those of major importance required in relatively large quantities (C, H, O, N, S, and P); micronutrients are also important but required in smaller quantities (Fe, Mo).

NYMPHS - Immature stages of Arthropods with incomplete metamorphosis (primarily insects).

ORGANISM - Any living or recently dead thing.

PED - An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

PERCHED WATER TABLE - A layer of saturation in the soil, separated from the true ground water table and held above it by a layer of impervious material.

PERMEABILITY - The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.

PER CENT SODIUM - The proportion of sodium ions among the aggregate cation concentration of calcium, magnesium, sodium and potassium.

PESTICIDE - Toxic chemical used for killing organisms. Usually widely toxic to living things.

pH - ("power hydrogen") negative logarithm of hydrogen-ion concentration, a numerical expression of acidity.

PHYSIOGRAPHY - A description of existing nature as displayed in the surface arrangement of the globe, its features, atmospheric and oceanic currents, climates, magnetism, life, etc., as well as the changes or variations to which these are subjected.

POLLUTANT - A residue (usually of human activity) which has an undesirable effect upon the environment (particularly of concern when in excess of the natural capacity of the environment to render it innocuous).

POPULATION - A group of organisms of the same species.

PREDOMINANT - An organism of outstanding abundance or obvious importance in a community.

RECENT - Informal, (geological) usually referring to the period of time from the last glaciation to the present. U.S.G.S. uses it formally, as Recent, but has not defined it; most geologists prefer "Holocene".

RESERVOIR - An artificially impounded body of water; also, the supply of any commodity, as a reservoir of infection, etc.

SALINE (MARINE) - Having a salinity of greater than 20 ppt.

SANCTUARY - An area usually set aside by legislation or deed restrictions for the preservation and protection of organisms.

SEDIMENT - Any usually finely divided organic and/or mineral matter deposited by air or water in non-turbulent areas.

SHRINK-SWELL POTENTIAL - An indication of the volume change to be expected of the soil material caused by changes in moisture content.

SITE INDEX - A numerical means of expressing the quality of a forest site that is based on the height of the dominant stand at an arbitrarily chosen age; for example, the average height attained by dominant and co-dominant trees in a fully stocked stand at the age of 50 years.

SODIUM ABSORPTION RATIO - A revised form of the per cent sodium concept. It is expressed by the formula:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

(ion concentration in equivalents in millions)

SOIL PROFILE - The sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

SPECIES DIVERSITY - Refers to the number of species or other kinds in an area, and, for purposes of quantification, to their relative abundance as well.

SPECIES DIVERSITY INDEX - Any of several mathematical indices which express in one term the number of kinds of species and the relative numbers of each in an area.

SWAMP - A flat, wet area usually or periodically covered by standing water and supporting a growth of trees, shrubs, and grasses.

TAXON (pl. taxa) - Any taxonomic unit, from biotype or ecotype to phylum or kingdon.

TERRACE - Any level-topped surface, with a steep escarpment, whether it be solid rock or loose materials.

TEXTURE, SOIL - The relative proportion of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse", "fine", or "very fine".

TRANSMISSIVITY - Transmissivity is the rate of flow of water, in gallons per day, at the prevailing temperature, through a vertical strip of an aquifer one foot wide extending the full saturated height of the aquifer, under a hydraulic gradient of 100 per cent which means a one foot drop in water level or head in a one foot flow distance.

UNIT HYDROGRAPH - A discharge hydrograph coming from one inch of direct run-off distributed uniformly over the watershed, with the direct runoff generated at a uniform rate during the given storm duration.

WASTEWATER - Water derived from a municipal or industrial waste treatment plant.

WATERFOWL - Birds frequenting water; ordinarily referring to game birds such as ducks and geese.

WATER TABLE - The upper limit of that part of the ground which is saturated with water.

WATERSHED - An entire drainage basin including all living and non-living components of the system.

WILDLIFE - Undomesticated animals; often hunted or at least noticed by men, and, therefore, consisting mainly of mammals, birds, and a few lower vertebrates and insects.

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